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SIMILARITIES AND DIFFERENCES BETWEEN FACIES, FACIES-CYCLIC, AND FACIES-TECTONIC METHODS OF THE STUDY OF COAL MEASURES

by

Yu. A. Zhemchuzhnikov

This discussion is important from a purely ractical point of view: on one hand, no con- radictions and differences in principle should e found where there are none; on the other and, true similarities and divergences of idividual points of view should be established.

At the First Geological Conference on Coal, ı 1944 [see TRUDY INST. GEOLOGICHESKIKH AUK AN SSSR, no. 90, 1947], there were vo schools of thought on problems of coal geo- ›gy: the so-called "cyclists" and the "anti- yclists."

At the Second Geological Conference on oal, in March 1955, several (classification) ıethods were described in papers by G. A. vanov [12], T. A. Ishina, V. V. Koperina, . V. Rengarten, E. A. Slatvinskaya [14], u. A. Zhemchuzhnikov and V. S. Yablokov [7], . N. Botvinkina [3], A. G. Kobilev and V. S. azarev [15] and others. No cognizance was ıken of the methodologies worked out by a eam of the All-Union Institute of Mineral Raw laterials [VIMS: G. F. Krasheninnikov and thers], which had been "anticyclist" at the 944 conference.

G. A. Ivanov and the author maintain (as do thers) that periodicity of sedimentation is one f the paramount characteristics of coal meas- res [Yu. A. Zhemchuzhnikov: 4, 5, 6, 7; . A. Ivanov: 8, 9, 10, 12]. Therefore, it is xpedient to clarify similarities and differences ı concepts as they become apparent, espe- ially in connection with Ivanov's paper at the econd Geological Conference on Coal.

It is assumed that Ivanov first observes the cies, then considers geotectonic problems, ıus: facies-geotectonic. This is not so: either facies nor the geotectonics as such, is e direct object of his studies.

The method differentiates granulometric ırieties; coals and limestones are taken to be e finest grained rocks. Carbonaceous argil- te and marl, argillite, siltstone, and fine, edium and coarse-grained sandstones are epresented in the columnar section by ever-widening strokes, thus graphically illustrating granulometric varieties. The smooth granulometric curve adds little to the section thus represented.[1] Graphic representation has been used by many foreign and Soviet authors (as for instance Yu. A. Zhemchuzhnikov and E. P. Bruns, Wanless, and others). G. A. Ivanov considers the drafting of sections and the drawing of granulometric curves mandatory in all cases. The section is automatically divided into granulometric rhythms (or cycles) by this method. Index beds are separated by other properties: beds and seams of coal, beds with traces of root systems, limestones, beds with marine fauna, erosional surfaces (continental, with river deposits above them), and bar sandstones.

In subsequent steps Ivanov gives a first approximation of the elevation of a bed or group of beds, relative to sea level, and the direction of deposition: transgressive or regressive. However, this is not always possible, and often leads to controversial results.

As the second step, differentiation of facies, and especially of uplifts and subsidences, is refined on the basis of assorted properties (of the rocks). A regressive facies assemblage form in a stationary area, or in a depression undergoing sedimentation (pseudoregression).

G. A. Ivanov points out that a discrete lagoonal-marine rhythm, corresponding to a single oscillation, may consist of two full granulometric rhythms. It follows that both the transgressive and the regressive movements may consist of half of the granulometric rhythm (lagoonal rhythm) in some cases and all of it in others (lagoonal-marine).

Thus, the granulometric and the geotectonic rhythms do not coincide in general; and the direction of movement may coincide with or be

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[1]Many of the limestones in coal measures, as well as shell beds, consist of coarse shell fragments. In grain size they correspond to gravel beds.

opposite to granulometric changes. However, Ivanov attributes great value to the granulometric approach, as the initial step.

Its second feature is early identification of geotectonic conditions, which "determine such essential properties of the coal measures as orderly sequence, the character of contacts, thickness, areal extent (including those of coal beds, wedging out, splitting, and other geologic peculiarities, i. e., all the basic quantitative data of sedimentation and coal formation." [12, p. 149].

In § 7 of his summary, G. A. Ivanov defines this sequence of operations: "In the facies-geotectonic analysis, regular complexes - sedimentary rhythms - are separated at the outset during the drafting of a section with a granulometric curve, as granulometric rhythms with an orderly assemblage of facies corresponding to the conditions of sedimentation. Then, in the analysis of a section by its lithologic properties, the granulometric rhythms are generalized into the facies-geotectonic, reflecting the interaction of the facies and geotectonic factors of sedimentation and coal formation [12, p. 151].

Ivanov particularly emphasizes that the facies-geotectonic method, based on granulometric description and on designation of index facies (markers), is simpler than determining all of the facies, as in other methods.

This argument is vulnerable. It is obviously easiest to mark off granulometric divisions and draw a granulometric curve. The result is "the granulometric cycles." But, as is evident from Ivanov's paper, a true "genetic" cycle connected with geotectonic movements may contain two or three granulometric cycles. Therefore, the establishment of the latter is only the beginning of the problem. The designation of "index facies" is no less difficult for a sample collector than that of any facies, especially in localities where limestones and marine beds are lacking, and "facies analysis" and an identification of cycles is essential. For nonparalic basins, i. e. for most of the Mesozoic and Tertiary coal basins, and some of the Permian (Kuzbass), the Ivanov method is not less complicated.

Generally speaking, does one measure the efficiency of a method by the ease of its adaptation by assistants-collectors and by poorly trained "latter-day geologists?"

This, of course, is not the case. First, an average collector has no business to occupy himself with facies, since this requires a broad geological training, which he lacks as a rule. Second, a collector should be trained and promoted to geological technician, if he is to be entrusted with a more responsible task.

Finally, why should every special method, in fully developed form, be completely assimilated and turned down cold if not so assimulate Such an approach excludes extended geological mapping: petrographic, paleontological, geophysical data, etc. - all of which require considerable specialized training, and an enginee ing and scientific approach.

Ivanov's specification is valid only when the method is applied to local conditions, but is invalid relative to the method itself. There are a number of techniques, especially labora tory techniques, which are unsuitable for use in the field. But should they be rejected instead of being made a component of the complex study of coal measures and useful minerals. Of course not; therefore the criteria of simplicity and accessibility to untrained persons are invalid in an evaluation of efficiency of a method.

Ivanov's method differs from the facies-cycl analysis as follows: "It (his method) does not require preliminary separation of the several lithogenetic rock types and the determination o their facies affiliation, which is time-consuming, poorly adapted to exploration techniques, and considerably subjective. There is no necessity of preliminary generalization into orderly complexes corresponding to facies groups (facies environments), or of differentia tion into the sedimentary rhythms or cycles of this or that facies composition, on the basis of a repetition of such complexes" [12, p. 151].

Thus, according to G. A. Ivanov, his metho is faster and more objective in determination o facies and facies complexes, with the basic cycles or rhythms separated (finally) not subse quent to, and not on the basis of a detailed facies study, but prior to that and on the basis of the easily applicable granulometry.

Roughly, he proposes a "cycles-to-facies" method of determination, instead of a "facies-to-cycles," and he regards his method as less painstaking and more precise (not subjective). It should be noted that even the facies-cyclic method of facies determination uses paragenesi and position in the assumed cycle, besides obvi ous lithogenetic properties. Facies and cyclic aspects are interdependent, but a true final separation of cycles and of rhythm character is possible (only) after firm establishment of the facies.

If Ivanov's method were faster than the other in facies determination, it could be recommended as the most effective in facies identification. However, the problem is not that simple. Ivanov does not identify individual facies or individual lithogenetic types, but groups of facies in contact with the index facies. However, if a section contains few if any limestones, and no well-defined sand bars - which is not uncommon even in a lagoonal-marine

environment (the Donets coal measures) - the facies determination becomes difficult and will be too generalized.

At the same time, G. A. Ivanov regards this determination of the facies (and types) by lithology as too painstaking, and sees no need of refining these methods. He relies on "general geological considerations" and the Golovkinskii-Walter law of migration of facies, which, by the way, does not always hold true.

Thus, according to Ivanov, restoration of individual fractional facies, and its application to paleogeographic maps and other data is neither the purpose nor a result of the facies-geotectonic method. On the other hand, it turns out to be applicable, in its present form, only to a typical lagoonal-marine environment, i. e., in the presence of bar sandstones, a marine fauna, etc., that is to certain paralic coal measures of the Carboniferous and Permian. For other series and basins of the Permian and Mesozoic, chiefly continental, another approach is apparently necessary, as Ivanov himself admits. In his opinion, his method "becomes complicated when applied to intracontinental coal measures, which are little known as a rule" [12, p. 151]. One could take issue with the last statement, since the Kuzbass coal measures (Permian), Chelyabinsk Basin (Rhaetian), Central Asia (Lower Jurassic), Burei (Upper Jurassic-Lower Cretaceous) and others, are adequately studied as far as facies are concerned. However, the application of Ivanov's method is not clear.

As regards the facies-cyclic method, its validity has been confirmed in the Kuzbass as well as in many other basins, including the Jurassic [1, 3, 4, 13].

In summary, it can be emphasized that the facies-geotectonic analysis proposed by G. A. Ivanov has much in common with the facies-cyclic method, since both unreservedly recognize facies and cycles (rhythms) and regard the rhythm as a result of oscillating motion against a background of general subsidence. It is quite probable that in the Pechora Basin, and especially the Vorkuta series, in which lagoon and marine facies predominate with infrequent erosion and alluvial facies, Ivanov's method will be the most effective. It puts more emphasis on the granulometry and cyclicity and less on facies, which are considered in groups. For a shallow marine environment, on the other hand, or for its opposite, an intracontinental environment where the coal measures present almost a single genetic group of rocks, a more detailed facies analysis is required; here the cyclicity is less discernible by its purely natural (as opposed to facies) characteristics.

With certain specific differences, the facies-geotectonic analysis is more like the facies-cyclic, as opposed to the pure facies analysis, which ignores cyclic regularity in general. It differs also in its application to the identification or refinement of facies. The theoretical premises of both are similar and may be contrasted with those facies analysis methods which do not relate cyclicity or rhythm with geotectonic movement, or else completely ignore them. Therefore the cyclicity of a section is apt to appear as a fortuitous, local, or transient phenomenon, present in one series or basin, and lacking in the others.

It is strange that the same idea of a facultative quality of rhythms has been arrived at by those investigators who cite intermittent subsidence, with pauses but without any uplift (according to Pryuvo). The assumption that some series are cyclic while some others are not is inconsistent, since the concept of a periodically intermittent subsidence and that of periodical uplifts and subsidences are close to each other in consideration of the permanency of this tectonic factor. Therefore, we shall cite the opinions of some authors who attended the Second Coal Conference, where Ivanov read his paper.

The paper by T. A. Ishina, V. V. Koperina, N. V. Rengarten and E. A. Slatvinskaya [14] presents interesting data on the practical results of facies analysis, dealing chiefly with well-cuttings and core material. However, in regard to "the practice of geological prospecting," only a recommendation at the end of the paper deals with a wider assimilation of the "methods of facies analysis" [14, p. 160]. The method itself is thus defined by the authors: "The gist of the facies analysis method is a study of the primary or genetic rock properties which originate in the process of sediment accumulation and its diagenetic changes. On the basis of the sum of these properties, conclusions are reached as to the condition of sedimentation, and the facies composition of the coal measures is established." [14, p. 133].

Such a definition is somewhat limited. It does not take into consideration, in the facies identification, the meaning of the rock sequence, the paragenetic combinations, i. e., their vertical changes, and the proximity of facies changes throughout the area. All these aspects are likewise applicable to a refinement of the facies.

This definition is too narrow even as applied to the factual material cited by the authors. After a recital of a number of genetic properties, it is pointed out on p. 154 that, in addition, "it is essential to take into consideration the thickness and extent of the beds, their paragenetic relationships and the character of the facies-to-facies transition" (Underscoring mine. Yu. Zh.).

Undoubtedly, the paragenetic relationships and the transitions or alternations have certain regularities which should be taken advantage of,

and which doubtless are so used by the authors occasionally. However, the authors neither mention nor include them in their method of facies analysis, thereby narrowing their own approach to the problem and limiting the possibilities. This also determines the authors' approach to those regularities which are determined by the widespread phenomenon of periodic sedimentation. For a clarification of this point, we quote freely from their paper.

The authors stated, "In some instances of the lithologo-facies study of coal measures, a regularity is observed in the build-up of the section - a rhythmic or cyclic alternation of the several facies rock types. When this rhythmic build-up of the section is sufficiently distinct, the facies-cyclic analysis method, developed by Yu. A. Zhemchuzhnikov in 1951, may be applicable" [14, p. 155].

But supposing the rhythm is not sufficiently distinct?[1] If the rhythm is difficult to establish, does this mean that boundaries need not be established at all? By the same token, if a facies is difficult to establish, are we to reject the facies method? Such conclusions are suggested by the somewhat negative approach taken by the authors. And the natural conclusion is, as we read further on:

"It is to be noted that a distinct (underscoring mine. --Yu. Zh.) rhythm in the formation of coal measures is not a universal phenomenon. The rhythm may be of different intensity, even within a single coal measure." [14, p. 155]. This is true, but what next? We quote the following instances:

"For instance, the most distinct rhythm in the Donets basin appears in series C_2^5 and C_2^6." This is not true, as series C_2^7 and others (C_2^3 and C_2^4), as well as the lower Carboniferous coal measures of the Donets, studied by a group from the AN SSSR Geological Institute, display sufficiently clear rhythm.

"In the Karaganda coal measures, the only clean-cut rhythmic accumulation is displayed by the Karaganda series (Ishina, 1954); it is not distinct in the underlying Ashlyarik series (Slatvinskaya, 1954), and not found at all in the overlying epi-Karaganda and Dolinsk series (Koperina, 1954); in the accumulation of the Ekibastuz coal measures, according to Ye. P. Butova (1954), no rhythm is observed" [14, p. 155-156].

A conclusion: "the facies-cyclic analysis is a special method to be used only locally in the study of certain series displaying a distinct (underscoring mine. --Yu. Zh.) rhythm" [14, p. 156].

This conclusion is consistent, but completely erroneous. Indeed, is it correct that the study of a given phenomenon, and the application of this or that method, are possible and practicable only in those cases when that phenomenon is manifested definitely and sharply? This, of course, is incorrect.

At the outset of any scientific research, much is obscure, and does not immediately arrest the eye, but becomes clear gradually in the process of study and application of effort. A time comes when one is amazed at his earlier failure to perceive definite relationships and regularities. There would be no new discoveries, no new methods if the scientist approached only what is obvious. The development of a method consists in the discovery of new aspects in a phenomenon, which are interconnected with the others but are not apparent at first glance.

If the cyclicity and rhythm are not a wanton "play of nature" but a definite pattern of sedimentation, connected with geotectonics, oscillatory movements, or even intermittent subsidence without uplifts - then they should be present everywhere. To be sure, the degree of expression may be different, and at times indistinct and obscure. Tectonic movements may be camouflaged by other phenomena which then should be deciphered and identified as the truly "special cases."

If the authors do not connect cyclicity and tectonic factors, they, together with many other lithologists at the First Coal Conference, underestimate that factor.

The strongest negative view of the oscillatory movement as a source (cause) of the rhythm, is found in the paper by V. V. Koperina [16]. That

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[1] The "distinction" of cyclicity, in its lithological meaning, in regards to rocks, depends primarily on granulometric diapason. If, within a cycle, the clastic rocks change from conglomerates to argillites, they are more "distinct" than the cycles with rock changes from siltstones to argillites.

A sharper distinction is also related to breaks and washouts at the base of the cycles. A combination of conglomerates and washouts, with a truncation of the upper parts of the cycles, results in the sharpest cycle boundaries. Some markers in the cycle, such as limestone and coal beds, enhance the distinction.

However, even though all markers are lacking, it is possible to identify them in nearly any coal-bearing interval with some effort. The rhythm becomes even more definite if the facies of a section are identified. Some coal measures do not display rhythm, but only under unusual circumstances such as when the normal course of sedimentation and coal accumulation is disturbed.

hythm which was observed in the Karaganda asin by other authors, V. V. Koperina is inlined to ascribe to an irregular but directed ubsidence or to "a migration of the facies ones in the conditions of an irregularly subiding sea shore."

Thus, a geotectonic explanation of the rhythm henomenon still remains in force. Such being e case, the cyclicity must be peculiar to all e series of the coal measures; however, its cal obscurity is what needs to be explained. he final conclusion that the rhythm is manisted in the built-up parts of the section only 16, p. 89] is not only doubtful but also amazing.

Unfortunately, the report by the four authors ontains no attempt to clarify the actual alteration of rocks and facies, for instance, interittent subsidence with pauses (Pryuvo's conept). The phenomenon is established dogmatially and is given the appearance of factual upport.

Let us look into those facts. T. A. Ishina, in e course of her work in 1954 [13], studied the ower part of the Karaganda series, which dislays many similarities to the Ashlyarik series nd must be taken to be its continuation. In at series, T. A. Ishina has found the cyclicity; hile Ye. A. Slatvinskaya, working contempoaneously, has not found any "distinct" rhythm.

The fact is that even the first impression of e Ashlyarik section testifies in favor of a eriodicity in the deposits of the Ashlyarik seres. Indeed, the section contains several dozen ather thin coal beds. Above them there are no ess than 12 established horizons with marine auna. Both are distributed fairly uniformly. n the middle portion are coarser-grained ocks. It would appear that, facies-wise as vell, the regularity of alternation should be ven more "distinct." It is strange that the indings in the basal Karaganda series, where he faunal horizons are less numerous, were ot carried over to this series.

V. V. Koperina has found no cyclicity in the pper Karaganda series; and Ye. P. Butova has ound none in the Ekibastuz. On the other hand, T. A. Ishina [13, p. 157] has identified a disinct rhythm within the Jurassic of southern Yakutia - this despite the uniformity of related ontinental facies: channel, flood plain, lacusrine, and marsh. Each rhythm is 200-250 m hick; there are four in all. T. A. Ishina very easonably proposes to regard each of them as n individual series, as they are widespread really. The upper, shortened rhythm suggests a development of the upper coal measures lsewhere. Thus, the "cyclic" approach has ed to a number of important practical conclusions.

The report of the four authors also mentions that a litho-facies study of the section by N. V. Rengarten and Ye. A. Slatvinskaya, in 1952, on the basis of rhythms in the Taldy-Kuduk area of the Karaganda, has shown that the section lies in a normal position and is fully correlative with adjacent areas.

All these examples suggest a conclusion: those who accept rhythm in nature will find it even where it is rather indistinct, and they will arrive at proper conclusions. Those who do not want to, will not find it even where it is obvious. Scepticism and a negative view of the cycles and of definite facies (such as fluvial) hinders the understanding of the part played by tectonic movements in sediment accumulation, and consequently the understanding of the true cause of rock alternation.

In summary, it can be said that as soon as the lithologists apply the facies analysis in its advanced form, i.e., the facies-cyclic method, broader results and further development of the method itself will be achieved. When, on the other hand, lithologists circumscribe their own field of action, or when the material is not fully utilized, then the approach and the results are limited.

Coming back to the four authors' definition of the facies analysis [14, p. 153] as a study of the several primary properties, we are forced to say that it is not only incomplete and narrow but applicable only to special cases where the material was insufficient or characterized by a lack of time and attention on the part of the investigators. In a more general case of the lithological study of coal measures, the facies analysis should be carried on with regard to 1) genetic features of the sediment; 2) areal distribution and change; 3) its place in the vertical, alternating rock series.

As previously mentioned, the authors themselves have introduced the second and third points in the study program [14, p. 157], but in an irresponsible way, having left them out of the definition.

The fact is that, with the exception of the above-mentioned special cases, the authors of the paper, or some of them in their individual work, are guided by a broader and more general facies-cyclical method, unaware - either consciously or not - of the fact that they, like one of Moliere's characters, are "speaking in prose."

Thus, the paper by the four authors suggests that in order to understand the true situation in the lithology of coal measures, a further exchange of opinion and experience is necessary, as well as a discussion of the subject and a critical approach to any distortion of the perspective or the history of the problem, such as those encountered in the paper by G. F. Krash-

eninnikov [17, p. 35]. He points out that the facies analysis originated in the All-Union Institute of Mineral Raw Materials (VIMS), citing the paper by T. N. Davydova and Ts. L. Gol'dshtein, and also the fact that the basic premises of that truly excellent work were presented at the First Geological Conference on Coal, in 1944, and published in the proceedings of that conference, in 1947.

At the same time G. F. Krasheninnikov says nothing of the fact that a number of papers and theses at that conference revealed another direction in the study of coal measures (in papers during 1933-1943, by G. A. Ivanov, Ye. P. Bruns, Yu. A. Zhemchuzhnikov, N. N. Forsh, and others), which, together with the facies, regarded the rhythm (cyclicity) as a manifestation of tectonic movements, while G. F. Krasheninnikov and some other champions of the VIMS facies method underestimated the tectonic factor. It should be noted that in the paper on Bureya, by T. N. Davydova and Ts. L. Gol'dshtein, one of the series was described as Rhythmic.

However, contrary to all known facts, G. F. Krasheninnikov takes it upon himself to state that "at the present time, such (i. e., of the VIMS kind. Yu. Zh.) practices, known as the facies analysis method and the facies-cyclic method, have received especially wide recognition and are successfully used in a number of coal basins (Donets, Karaganda, Kuznetsk, and others)." What conflicted in 1944-1947, G. F. Krasheninnikov, in 1956, wants us to accept as having originated in each other.

This, of course, contradicts the historical record. It would be more correct to say that the progress in the study of the lithology of coal basins has enriched the entire field of Soviet thinking on facies.

It would be a welcome circumstance if the two currents of 1956-1960 merged into a single lithologic stream, with a well-developed (on the basis of the attainments for the last 20 years) facies analysis and a far-advanced (during and after the war) rhythm and cyclicity analysis. In any event, the foremost Soviet lithology of the Sixth Five-Year Plan must assimilate the great advances in both approaches, in order to maintain its high level.

We are inclined to give the following answer to the question posed at the beginning of this paper: at the present time there are no insurmountable differences in these approaches, provided they are not circumscribed by an artificial denial of the geotectonic factor of rock alternation, or by ignoring the value of a study of the individual lithologic properties of rocks, and the importance of the facies differentiation by all accessible methods. The periodicity, as expressed in various stages and forms, cannot but become a mandatory element of any lithofacies study of coal measures.

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FACIES AND TYPES OF COAL ACCUMULATION IN THE DONETS COAL MEASURES

by

V. V. Koperina

ABSTRACT

A review of facies content of rocks in the Donets coal measures, shows that facies changes through the section may be explained by the change in relationship between the rate of subsidence and the rate of sediment accumulation and not by oscillatory movements.

Two types of coal accumulation occurred in the Donets: 1) along a flat littoral zone, protected by sand bars; 2) in a delta area with a migratory river mouth.

A comprehensive survey of the facies of the Donets coal measures reveals a regular relationship between facies and coal deposits and also other properties of coal horizons; it facilitates identification of two types of accumulation, characterized by definite facies aspects and varying petrographic composition and other properties. An analysis of the facies partially clarifies the problem of tectonic movements occurring during deposition; thus, the facies change can be explained by subsidence and oscillatory movements can be disregarded.

This paper is based on geologic studies performed, as well as on our observations in the central Donets in 1948. The section, C_2^1 to C_3^1, inclusive, was investigated in outcrop, well cuttings, and cores. Well cuttings and cores from the lower Carboniferous coal measures, C_1 to C_5, were studied by the author throughout the area of activity of the Trudov geological-exploratory party (40-60 km southwest of Stalino).

The base of the coal measures consists of Tournaisian and Visean limestones with normal marine fauna. This segment is 100-500 m thick and is designated as series C_1^1(A). Nearer the surface, carbonates are gradually replaced by thick upper Visean (C_g^V) terrigenous deposits. This portion is productive toward the top; it is divided into a sub-coal-bearing series; (C_2^1(B)) 300-600 m thick and a coal bearing series (C_1^3(C)) 500-1000 m thick (thickness decreases westward). [1]

Siltstones and argillites predominate in the sub-coal-bearing series. In the lower horizons limestone beds are common and are characterized by a rich marine fauna. Higher up the section, the faunal content becomes more uniform, and the limestone beds less common and with evidence of littoral zone deposition (admixture of terrigenous material, sideritization or dolomitization). There are rare and discontinuous coal seams and carbonaceous rock. Limestone beds are even less common in the upper horizons of the sub-coal-bearing series where there is a considerable development of sandstone. The number of coal intercalations increases, with root remains appearing in fossil soil, thus relating the lithology and facies of the upper horizons of the sub-coal-bearing horizons and the overlying coal-bearing series, in that a gradual change of marine to littoral conditions is suggested.

The lower Carboniferous coal measures of the western Donets are composed chiefly of siltstones and argillites, often carrying coal intercalations and beds of workable thickness. The sandstones are comparatively rare and thin (most commonly 3 m, rarely to 15 m thick). Occasional limestone beds (0.1-0.7 m thick), chiefly finely detrital, crinoidal, occur locally with sand admixture suggesting a littoral origin. Two limestone horizons, considered to be the upper and lower boundary of the coal measures, can be traced over long distances (up to 100 km). The upper bed carries abundant marine fauna. In the argillaceous rocks the marine fauna is comparatively rare and mainly detrital. The lagoon-type fauna is more widespread. The argillites above the coal beds C_6^2 and C_7, which contain a diversified marine fauna are exceptions. Plant remains are rare; small amounts of fine detritus occur along the bedding planes.

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[1] Differentiation of the lower Carboniferous into series is based on A. S. Shirokov's paper given at the Second Geological Conference on Coal in 1955 [3].

Abundant root remains of Stigmaria fill the clay rocks of the fossil soil ("kucheryavchik" - curly rock) and also occur at the top. These are not related to the coal beds and often occur in layers up to 4 m thick. Alternations of thin siltstones and argillites or fine-grained sandstones, with numerous traces of boring animals and worms, are very common throughout the coal measures.

The coal saturation of the section is high (saturation coefficient 3.5 percent - maximum for Donets). The coal beds are thin (usually less than 1 m), with considerable areal extent (some can be traced over dozens of kilometers). The ash content is low, usually 4-7 percent, less commonly 10 or 12 percent; the sulfur content is 1.5-2.5 percent.

This brief description of the coal measures suggests that these rocks are related in that they originated under littoral and marsh conditions. Four alternating facies are fairly distinct throughout the section: 1) spits and sand bars; 2) lagoons and embayments; 3) near-shore shallows; 4) marshes.

Sand bar and spit facies are represented chiefly by fine-grained, well-sorted sandstones, with local crossbedding or indistinct ripple-marks with small amounts of plant detritus along the bedding planes. In the lower portions of sandy horizons occur irregular local accumulations of coarse plant remains, with occasional marine fauna. Locally, single intercalations of non-stratified gray argillite or siltstone from several centimeters to 0.5 m thick occur. Traces of boring animals are encountered locally in the vicinity of these layers, and at the base of sandy horizons. The sandstone contact is either gradual or sharp with no traces of erosion or coarse clastic material.

Lagoon and embayment facies. Dark-gray argillites and siltstones with obscure horizontal stratification occur here. Plant remains are absent except for occasional pyritized stem and leaf fragments. Thin sideritized intercalations and small irregular siderite concretions are very common. Marine fauna is rare; more common is the fauna characteristic of a brackish, lagoonal-type basin.

The near-shore shallow facies is represented chiefly by an alternation of thin siltstones and argillites or fine-grained sandstones. They are horizontal or lenticular layers, from several mm to 2-5 cm thick, with the sandy layers displaying poorly-developed cross-bedding. The bedding structure is frequently disturbed by traces of small boring animals and by worm tracks. Small amounts of plant detritus are common along the bedding planes. Less common are small fragments of pelecypods, brachiopods, and gastropods. Very rare among these facies are limestone beds, 0.1-1.0 m thick, mostly crinoidal or clastic, with sand-clay admixture.

Marsh facies comprise coals, carbonaceous rocks, and closely associated argillites and siltstones. They are massive or poorly stratified, with the stratification nearly totally obscured by the numerous root remains which cross it ("Kucheryavchik"). Some root remains occur within the stratified rocks of the near-shore shallow facies which usually underlie the marsh deposits.

According to S. V. Savchuk [12] and K. I. Inosova, the coal horizons are petrographically close to durains; they contain a considerable amount of cutinized material, chiefly microspores (10-40 percent), a poorly transparent ground mass (10-12 percent), and fusainized tissues (10-20 percent); the colloidal material content is low (30-60 percent). Most coals are foliated or finely banded, due to the alternation of fine, dull (durain) and semi-dull, semi-glossy (clarain-durain) bands. The spore distribution throughout the coal is mostly uniform within the beds.

Marsh, near shore, lagoonal and sand bar facies alternate throughout the coal measure section, mostly in horizons less than 10 m thick.

The paragenetic relationship of these facies is expressed by a definite sequence of alternation, which may be called "rhythmic construction of the section. The near shore shallow deposits, going upward, usually change into marsh facies, the "kucheryavchiks," and then into coals; the latter are usually overlain by argillaceous rocks belonging to the lagoonal facies. The sand-bar facies is not always present in the rhythmic construction; it is less common throughout the section and is nearly always separated from the coal beds by near-shore or lagoonal deposits.

This alternation of littoral facies suggests that the area of development of the sandy deposits was fairly distant from that of the coal. They were separated by a belt of shallow-water, near-shore and lagoonal facies. Apparently, the marsh-lacustrine basins of coal deposition were located in a flat shore fringed by a band of shallow water, not over 10 m deep, separated from the sea by a belt of sand bars or spits.

As shown by V.P. Zenkevich [7], facies distribution of this type is quite common; and is often observed in modern flat seashores. Sand bars and spits are formed under those conditions because the waves carrying suspended clastic material lose velocity as they travel over the flat incline, causing the coarser material to drop to the bottom at a considerable distance away from the shore. The sandy deposits thus formed facilitate a further development of this process; gradually a sand bar is formed on the

gently sloping bottom, some distance away from the shore, and all of the sand load of the waves is dropped there. Later on, these sand bars and spits may reach to the surface and enclose a shallow lagoon.

The distance of an incipient sand bar from the water line is determined by the slope of the bottom. The smaller the angle of the incline, i. e., the flatter the shore, the greater the distance to the sand bar. In the process of formation of the lower Carboniferous coal measures of the Donets, which took place over a flat, slowly subsiding shore, the distance from the bar to the shore was determined by the ratio of the subsidence speed to that of the accumulation of the sediments brought in by the sea. When the speed of subsidence was greater the angle of slope increased, and the bar advanced toward shore. When the speed of sedimentation was greater than subsidence, the bottom slope flattened out and caused the bar to retreat seaward. In the latter case, along a flat stretch of seashore protected by a bar or spit, conditions favorable for peat accumulation would gradually arise.

At the outset, the sandy shoal some distance away from the shore did not reach the surface; waves rolled over it, carrying fine clastic material; over a wide shallow belt between the bar and the shore, finely interbedded sand silts and clays were accumulated, and acquiring all the features as described above for the near-shore shallow facies.

Along with near-shore sediment accumulation the bar rose, finally separating the shallows from the sea, thus bringing about the lagoonal conditions.

Since the incipient lagoon was adjacent to a low seashore overgrown by dense vegetation, it is assumed that no clastic material was brought in from the land, while the gradual growth of the bar made the access of terrigenous material from the sea ever more difficult. Therefore, the filling of the lagoon by clayey sediments gradually slowed. When the area was completely isolated from the sea, only peat-forming processes were active. In these later conditions, the continuous, slow downwarping was no longer compensated for by sedimentation; this led to an invasion of the peat marshes by the sea and to the birth of a lagoon. Thus, under conditions of a continuously subsiding seashore, a migration of the facies could take place, and the formation of rhythmically built coal measures could occur.

A coal measure with wide development of lagoonal, near-shore, and bar facies, containing high-grade coal, was first described by G. A. Ivanov in the Vorkuty coal field [8]. In our opinion, his only error was in the interpretation of the rhythmic structure of the section: he explained this phenomenon by oscillatory movements. A periodic alternation of facies, however, may take place during continuous subsidence of the area of sedimentation, in those cases when the ratio of the rates of subsidence and sedimentation changes periodically because of a lack of uniformity.

The type of coal accumulation observed in the lower Carboniferous coal measures of the Donets may be called the low, sheltered shore type. This type is characterized by the following features:

1. The coal-measures facies content is monotonous. Besides the marsh facies, represented by coals and clayey rocks with abundant root remains, it includes the lagoonal, near-shore shallow, and bar facies as described above.

2. The marsh facies are underlain and overlain by the lagoonal and near-shore shallow facies.

3. Occasional, fairly thin limestones show the evidence of deposition in the shallow near-shore zone.

4. The coal horizon is considerably thick and has high saturation.

5. A rhythm is apparent in the construction of the coal measures, that is, a multiple repetition of genetically related facies.

6. The coal beds are comparatively thin and of wide areal extent.

7. The coals have a small ash content.

8. Cutinized and fusainized components distributed along the bedding are present in considerable amounts. Hence the coals display finely banded texture expressed in an alternation of semi-glossy, glossy, and dull varieties.

The thickness of the lower Carboniferous coal measures decreases westward, and increases north and northeast of the investigated section; this is accompanied by an increase in deep marine deposits: limestones and shales carrying a marine fauna, and by a decrease in coal content. The facies changes in the same way, upward in the section: the deposits of the upper coal measures are of a deeper variety and poorer in coal content.

The overlying rocks, 100-700 m thick, belong to the Namurian stage (series C_1^4(D) and C_1^5(E)).

[1]At present, the problem of the extent of the Namurian stage, and of the Lower-Upper Cretaceous boundary, in the Donets coal measures is being reviewed.

This part of the section is represented chiefly by light-gray argillites and siltstones, both with occasional marine fauna. Sandstones account for an insignificant portion of the section. There are numerous (over 50) limestone beds with abundant and diversified fauna. Many corals occur in the lower part of the interval. There are occasional coal intercalations, but only one of them (e_g) is of workable thickness. Marine facies predominate in this part of the section. They cannot be further differentiated for lack of data [5].

The lower middle Carboniferous series, C_2^1 (F) and C_2^2(G), are similar in lithology and facies. The overall thickness reaches 1000 m in western Donets (main anticline area). Dark-gray argillites and siltstones, lacking any plant remains, and marked by obscure horizontal stratification and thin, lens-like siderite concretions are most common here. Occasional brachiopods, pelecypods, and gastropods are encountered. Siltstones and argillites, alternating in thin, poorly-outlined layers, form horizons 50-70 m thick, locally enclosing limestone beds with marine fauna. Periodically, fine-grained sandstones occur up to 10 m thick, often lacking a sharp contact with the enclosing argillites. The sandstones display fine cross-bedding and oscillation ripples, with fine plant detritus and stem fragments accumulated locally along the bedding planes. The middle of the sand horizons is usually the coarsest grained, with silt partings and traces of ironized roots occurring in the upper parts. Occasional intercalations of carbonaceous rocks and coals in this part of the section are also located in the vicinity of the upper contacts of the sandstones, suggesting a littoral origin for the latter.

The formation of near-shore sandy sediments suggests a fairly steep slope. This possibly has determined the low coal-bearing capacity of this part of the section. Only one coal bed (f_1) in the C_2^1 series and two (g_1 and g_1^2) in the C_2^2 are of a workable thickness in limited areas of the Stalino-Makyev and Krasnoarmeysk regions.

In the upper part of the C_2^2(G) series, besides the above-described littoral sandstones, sandy horizons of considerable thickness occur (up to 40 m), apparently belonging to sea-current facies. Still higher in the section, in series C_2^3(H), these facies become widely developed and include the "golovinov" and "babakov" sandstones, which reach thicknesses of 100-150 m, in the upper and lower parts of the C_2^3 series. The most characteristic feature of the sandstones belonging to the sea current facies is an alternation of beds of different clastic material (polymictic) and quartz sandstones, 1-10 m thick. This cannot occur in sandstones of fluvial or deltaic origin; since it would entail a sudden and simultaneous change in rock composition over the entire watershed area, which is impossible in large rivers. The sandstones are usually thick with flat or oblique bedding planes. Finer cross-bedding (1-3 cm) developed in the oblique beds, with parallel bedding planes marking a change in mineral content. Oscillation ripples are observed at times, with wave lengths of about 2 m, and amplitudes of 20-30 cm. Plant detritus is lacking in the sandstones; coarse plant remains are rare. They occur as ferruginous or silicified stems and trunks. The coarsest clastic material is most commonly in the middle of the sandy horizons. The lower contact of the sandstones is distinct and locally eroded. The upper contact is sharp, with occasional well-developed current ripples. Locally, the sandstones enclose argillaceous rocks with traces of roots and coal intercalations; therefore accumulation took place near the shoreline.

As previously mentioned, these sandstones make up the lower and the upper portions of series C_2^3(H); the middle part of this series is comprised chiefly of argillaceous and finely clastic rocks, up to 300 m thick. An alternation of argillites and siltstones occurs frequently in thin layers. Traces of small pelecypods (1-3 cm) of a single genus with thin shells are evident. Plant remains are more common than in the underlying series C_2, but rarely well preserved; usually they are minute fragments of leaves and stems. There are traces of roots, locally accompanied by coal layers, which sometimes attain workable thickness. Rare limestone beds, composed chiefly of Donacella detritus, occur among these rocks.

The middle of series C_2^3 is composed of near-shore shallow facies, and lagoonal and embayment facies all displaying a certain similarity to the lower Carboniferous coal measure facies, although bar sandstones are absent and the rhythm is generally not well expressed. The seashore was probably insufficiently flat, thus sand bars and vegetation were lacking. As a result the rocks are poor in root remains, and coalbeds are rare, thin, and of small areal extent. However, in certain areas a number of coalbeds in series C_2^3 attain workable thickness (h_3, h_7, h_8, h_{10}, h_{10}^1 and others).

The overlying series C_2^4(I), about 300 m thick (in the central region), also is composed chiefly of argillaceous rocks belonging to shallow sea and lagoonal facies. These rocks locally carry marine or brackish fauna and are interbedded with thin limestones. An alternation of argillites and siltstones with fine-grained sandstones, typical of shallow seashore facies, is fairly common. Occasional layers of thin sandstone, with roots remains and partings of carbonaceous rocks and coals locally occur near the top. Industrial coal in series C_2^4 occurs chiefly in the eastern parts of the Donets (Shakhta-Nesvetayev area) where several workable coal beds are known. It is of interest that

the increase in coal is accompanied by an increase in the amount of sandstones. This suggests that the industrial coal accumulation over this area is related to a development of deltaic deposits, which are widespread in the overlying series.

According to the data by K.N. Inosova, the coalbeds of series C_2^3 and C_2^4 are represented by banded clarain with partings of semidull coals rich in spores. Thus, these coals possess certain features transitional from the cannel durains of the Lower Cretaceous to the clarain coals characteristic of the overlying series.

Series C_2^5(K), C_2^6(L), C_2^7(M), representing the bulk of the middle Cretaceous Donets production, are similar in lithology and facies. Great similarity is noted in series C_2^5 and C_2^6 (with overall thickness of about 900 m in the studied section). The coal saturation is maximum for the middle Cretaceous ; the coefficient of coal saturation attains 2-3 percent. The coalbeds are distinguished by their wide areal extent, low ash content (average 14 percent), and simple structure. [1]

A lithologic feature of this series is a periodic reappearance of fairly thick sandstones genetically related to river activity. The number and the thickness of sandy horizons increases in the western and southern parts of the Donets. A decrease is noted to the north and east where argillaceous and carbonate rocks are developed, with an accompanying decrease in coal content. In the western Donets, the sandstone content is 40-60 percent; the sandstones alternate with siltstones and argillites, which include limestone and coalbeds. A definite rhythm appears throughout the section; as the rocks alternate in orderly sequence toward the top, the sandstones become fine grained and change to siltstones and argillites which contain numerous root remains at the top ("kucheryavchik"). These rocks are overlain by a coalbed and a limestone. Above are argillaceous rocks, locally fairly thick and often carrying marine or brackish fauna. These rocks show traces of erosion and are usually overlain by sandstone of the next cycle.

This rhythmic structure is typical throughout the western Donets; simpler rhythms are also present here. Some of the components are either lacking or poorly developed. Locally, limestones are missing, and the sandstones at the base of the cycles are inconspicuous, as are the argillaceous rocks above the coalbed.

The sandstone content in series C_2^7(M) (500-600 m thick) is considerably less than in series C_2^5 and C_2^6; at the same time coal content decreases (average 1.2 percent) and the areal extent of the coal beds decreases with it. although the grade of coal does not change. The amount of limestones increases in this series, but the limestone beds are not associated with the top of coal beds as in series C_2^5 and C_2^6. It should be also noted that the rhythm is not as well-developed in series C_2^7 as it is in series C_2^5 and C_2^6.

The facies content of series C_2^5 and C_2^6 and of the lower part of C_2^7 was studied in detail by a group of the IGN AN SSSR associates under the guidance of Yu. A. Zhemchuzhnikov: V.S. Yablokov, L.N. Botvinkina, A.P. Feofilova, P.P. Timofeyev, Z.V. Timofeyeva, M.I. Ritenberg, and S.E. Koltukhina. They recognized three facies groups which were components of these series: marine, transitional, and continental.

The marine facies are widespread in the lower series, and were briefly described above. Here we only note that the sea-current sandstones, which attain great thickness in the lower series, are very poorly developed in series C_2^5, C_2^6, C_2^7, while the littoral sandstones are totally lacking. The limestones of these series are chiefly shallow water, as they are represented mostly by detrital varieties.

The lagoonal and embayment deposits are well developed in series C_2^5 - C_2^7; they are classified by the above-mentioned investigators with the transitional facies group. Since these facies were described in the lower series, we shall not discuss them further. The investigators also included with the transitional facies group the sands dumped by the rivers, the sand deposits of bars and spits, and the sandy and argillaceous sediments of the maritime lakes. The facies maps of series C_2^5 and C_2^6, by L. N. Botvinkina and A. P. Feofilova[2] show these facies are closely related in their areal distribution to channel and floodplain deposits, which are separated into a group of continental facies. The maps also show that all these facies - channel, flood plain, sands dumped at the river mouth, sand bars and spits, sandy and argillaceous deposits of maritime lakes - are all accumulations of clastic material at the river mouths and represent essentially deltaic deposits.

It must be noted that Yu. A. Zhemchuzhnikov and his associates avoid the words, "delta" and "deltaic deposits," using instead, "alluvial deposits," "lower river valleys," and "mouth of river valley." However, their "alluvial deposits" are very indefinite; while to give the name

[1]Data on coal are from the collection Geologo-Uglekhimicheskaya karta Donetskogo basseina, 1950, no. 6, and 1954, no. 8 [4].

[2]Numerous facies maps were presented by L.N. Botvinkina and A.P. Feofilova at the Moscow Naturalist Society (MOIP) in 1954 and at the Second All-Union Conference on Coal in 1955 [2, 16].

of river valley to a delta is not quite correct, since a valley is a form of relief, which has no place at the mouth of a river pushing its delta into the area of shallow sea waters and building up extensive and flat delta plains. This is observed in numerous places in the Donets coal measures.

The papers by Yu. A. Zhemchuzhnikov contain direct references to the effect that alluvial deposits in the Donets coal measures, are deltaic deposits. He writes, "the combination of facts for any alluvial group of rocks suggests the mouth conditions of a single river or of a number of channels, i. e., the environment of a lower river valley or a terrestrial delta" [14, p. 290].

Inasmuch as the deltaic deposits are initially well-developed in series C_2^5 and C_2^6, a brief description of their component facies is given after Z. V. Timofeyeva [15].

The most widespread is the river channel facies, represented by sandstones, usually with coarse clastic materials with variegated pebbles and carbonized remains of stems and tree trunks at the base. The underlying rocks show many traces of erosion, to a depth of 10-12 m. The middle of the river channel deposits usually consist of coarse to medium-grained sandstones with some gravel and pebbles. Oriented cross-bedding is typical of these beds, with rhythmic sorting of clastic material: a gradual decrease in grain size for each oblique bed, from the base up. These oblique layers are joined into fairly thick (0.2-0.6 m) lentils separated from each other by sharp angular unconformity. Upward, the medium-grained sandstones gradually change to fine grained with fine cross-bedding, current ripple marks, and cross-current ripple marks. The clastic material is poorly sorted and only slightly rounded. Fauna is lacking. There are fairly numerous admixtures of plant detritus along the bedding planes. The river channel sandstones are 20-30 m thick.

The flood plain facies is represented by an alternation of siltstones, argillites, and fine-grained sandstones in small lentils (5-15 cm). The stratification is thin, lenticular-wavy and cross-wavy. The orientation of the cross-bedding and the inclination of the layers are variable. There is an abundance of plant remains accumulated along the bedding planes. Fauna is lacking. The flood plain deposits are usually thin, locally altogether missing; in such cases, the river channel sandstones lie directly under the subsoil and coal soil rocks.

The river mouth facies, bars, and spits are represented chiefly by fine to medium-grained sandstones showing obscure horizontal and fine, intermittent cross-bedding, with flat angles of incline. The grain sorting is spotty, with an alternation of beds having different granulometric composition. There are occasional siltstone intercalations with inclusions of flat, rough pebbles of the same rocks. The coarsest material usually lies in the middle part of these sandstones. Carbonized stem fragments, plant crumbs, etc. are fairly common. Locally plant detritus is distributed along the bedding in large amounts, accounting for the dark color. Fauna is lacking. These sand deposits are up to 15-20 m thick. In the section and throughout the area they are associated with river channel facies and tidal-lagoonal shallow seashore facies.

A detailed lithofacies study of series C_2^5 and C_2^6, including facies maps, as carried out by a group of lithologists under the guidance of Yu. A. Zhemchuzhnikov, show that the river mouth or delta deposits were periodically extruded into the Donets area from the west and south. In the northern and northeastern Donets, the channel and flood plain deposits, as well as the closely related river mouth deposits, bars, and spits, are replaced by the near-shore and lagoonal deposits.

Facies maps by L. N. Botvinkina and A. P. Feofilova [2, 16] show the facies distribution at the time of greatest development of sandstones; the same maps show coal distribution and industrial coal accumulations for the following period. This method of illustration graphically shows that the coals fully occupy the areas of sand development (corresponding to deltas) and spread over adjacent areas, with maximum coal development concentrating directly over the central part of the deltas. Later on, the same areas became sites of maximum development of carbonate deposits, as is shown by lime isopachs drawn on the same facies maps.

These facts suggest that the wide areas of deltaic sedimentation subsequently presented the most favorable environment for the formation of coal beds and limestones, i. e., rocks whose origination depends on minimum influx of clastic material. It is to be noted no river channel traces have been observed over the area of distribution of these rocks; on the contrary, they are best developed over the central part of the deltas, which means that no river channel existed at that time. Later on, the river mouth reoccupied this area, causing an accumulation of delta sand deposits - the onset of a new cycle. Such facies changes, as observed throughout series C_2^5 and C_2^6, may be best explained by periodic migration of the river mouth, as pointed out by D. V. Nalivkin, in his time.

The migration of a river mouth located in an area of prolonged downwarping, may be determined by the activity of the stream itself, that is, an accumulation of sand at its mouth. When, in the process of slow subsidence of a vast delta area, the speed of sediment accumulation at the mouth of the river exceeds that of the subsi-

dence, the absolute markers of the river mouth will rise gradually; because of that, the stream may work its way in the direction of a steeper slope and form a mouth where no delta deposits had previously accumulated. The instances of notable river mouth migration, occurring for the reasons given, are supplied by the Hwang-Ho, Mississippi, and other rivers.

Another explanation of the above facts is given by Yu. A. Zhemchuzhnikov, V. S. Yablokov, L. N. Botvinkina, A. P. Feofilova, and others: they ascribe all changes in the facies composition of coal measures to minor oscillatory movements which, they believe, took place during sediment accumulation [14].

In a number of papers, Yu. A. Zhemchuzhnikov and his associates assert that the river mouth deposits in the Donets area appeared as a result of uplift; they decreased with the submergence of the river, until they completely disappeared, with the phenomenon repeated many times during the coal measures' accumulation.

It is known that the magnitude of the river flow is determined by the watershed area and by the amount of precipitation, rather than by vertical movements at the mouth or the head of a river; the latter phenomenon affects the composition and the amount of the river load rather than the amount of flow. The mouth of a number of modern rivers is located in areas of prolonged subsidence (Mississippi, Rhine, Kuban', and others); however, there is no evidence of those rivers growing smaller or disappearing.

Thus, the ideas of Yu. A. Zhemchuzhnikov and his associates contradict observations of modern phenomena.

The conviction of Yu. A. Zhemchuzhnikov and his associates in the existence of oscillatory movements during the sediment accumulation is based not only on facies change throughout the coal measures but also on the presence of washouts at the base of river channel sandstones; the depth of such washouts attains 10-20 m, at times 30 m. Yu. A. Zhemchuzhnikov and others believe that this postulates a previous uplift of the river mouth, of the same magnitude.

However, a study of modern sedimentation shows that an explanation of this phenomenon is not to be sought in tectonic movements. At the present time, a secondary subsidence of dozens of meters, filled with the recent alluvium, has been established for the mouth portions of the Volga, Northern Dvina, Pechora, Kuban', Dnieper, Rhine, and many other rivers [11].

I. V. Samoilov [13] calls attention to an interesting coincidence: wherever a river mouth has been probed by deep drilling, secondary subsidence was established. Inasmuch as this phenomenon has been observed in all deltas, regardless of whether theyare located over rising or subsiding areas, it appears that the explanation is found not in tectonic movements but in the conditions of the hydrodynamic regime of the rivers.

Indeed, it is known that turbulent flow in the river channel results in an alternation of areas of maximum deepening of the bottom along its longitudinal profile - fairways; and the shallowest areas - shoals where deposition of the clastic river load takes place. The fairways and shoals are constantly displaced down the stream, replacing each other; thus, along the entire river course a deepening of the bottom occurs in the fairways, subsequently filled up by the sand of the invading shoals, with the depth difference attaining 10-20 m.

The same phenomena occur in delta channels; for instance, the deep bottom holes of the Volga delta, known as wintering places for fish.

Whenever a migratory delta takes over a shallow near-shore area, where sedimentation proceeds along the entire profile of the incline, up to water level, the delta channels will cut the sediments and wash them out. The depth of the cut will reach the maximum depth of the channels; this phenomenon in no way related to uplifts of adjacent highlands.

Thus a study of modern sedimentation leads to the conclusion that undercutting of the river channel sandstones and underlying rocks is not proof of oscillatory movements.

D. V. Nalivkin appears to be quite correct in his assertion that the formation of a rhythmic interval, with sandstones at its base, may proceed simultaneously with continuous subsidence of the area [10].

According to the data on hand, the process of formation of coal-bearing series C_2^5 and C_2^6 was as follows: during the accumulation of coal measures, slow differential subsidence took place throughout the Donets area, which was then occupied by a shallow marine basin, with speed of subsidence almost fully compensated for by sediment accumulation. The mouths of large rivers migrated, extending their deltas from the west, southwest, and south. As a result of intensive influx of clastic material, which overbalanced subsidence, a vast, flat delta plain with an adjacent peripheral shallow seashore covered the Donets.

Elevation of the delta surface, resulting from intensive sedimentation, subsequently caused inland migration of the river mouth, shutting off the influx of clastic material; the continuing slow subsidence was no longer compensated for by sediment accumulation, and the area of development of delta deposits was gradually submerged.

As the flat delta plain became a flooded marsh conditions became favorable for extensive peat accumulation over vast areas. A study of textural and structural peculiarities of the coal beds leads to the conclusion that the plant material was deposited subaqueously, at a possible depth of several meters [20]. Inasmuch as the slow accumulation of plant material could not keep up with the continued subsidence, further submergence led to the cessation of coal accumulation.

Later conditions favorable for the deposition of carbonate sediments developed, since the influx of clastic material was still obstructed. This may be the explanation for the frequent occurrence of limestone just above the coal beds. It is not to be assumed that the limestones signify considerable depth of water; all of the limestones in series C_2^5, C_2^6, C_2^7, are shallow water, with Donacella-detrital limestones considered to be of deepest origin. It is known that Donacella algae live at depths of 5 to 50 m; the depth of habitat apparently was close to the lower limit, which is suggested by faunal detritus commonly present in these limestones.

Inasmuch as the formation of carbonate deposits was slow and could not compensate for the continual subsidence, the depth gradually increased, thereby decreasing isolation from influx of clastic material from the sea. Consequently, thin areno-argillaceous deposits began to accumulate above the coal beds, locally building up horizons of considerable thickness. It can be assumed that during that period subsidence was almost fully compensated for by sedimentation, thus allowing a shallow basin to persist there for some time, until a new approach of a river mouth turned it into a delta area, thus heralding a new sedimentary cycle. During the formation of series C_2^5 and C_2^6, a migration of the mouth of the rivers led to an alternation of deltaic, marsh, and shallow marine facies, resulting in the rhythmic structure of these series.

A clean-cut relationship between coal development and distribution of sandstones, as established for series C_2^6 by A. Z. Shirokov [19], confirms the association of the processes of coal accumulation and the delta area. A facies study of series C_2^7 has shown that the coal is associated with deltaic facies; its content, however, is low because the delta deposits are not as widespread in that series as in series C_2^5 and C_2^6.

The coal accumulation in series C_2^5, C_2^6, C_2^7, has its own peculiarities and may be called migratory delta type. Its main features are as follows:

1. Delta facies are widespread throughout the coal measures, and are represented chiefly by fairly thick sandstones (a description of these facies was given above).

2. The facies content is often quite diversified; beside delta, the coal measures may contain littoral, lagoonal, lacustrine, marsh, and other facies.

3. The coal-beds are underlain by argillaceous rocks carrying abundant plant remains ("kucheryavchik").

4. Rhythm is well-developed throughout the coal measures.

5. The coal measures are very thick and contain many coal beds.

6. The coal beds, as a rule, are of minor thickness but of great areal extent.

7. The coals have a comparatively low ash content.

8. Petrographically, the coals are represented chiefly by glossy clarain, poorly stratified varieties, with great amounts of colloidal material and low content of fusainized and cutinized components. Sapropelitic coal seams occasionally occur in the upper parts of coal beds.

Industrial coal accumulation and delta facies in the Donets cease with the upper Carboniferous. A single bed (p_1), in the lower part of series C_3^1(N), attains workable thickness. Predominant in the upper Carboniferous section are lagoonal and shallow marine facies, among them the peculiar brecciated limestones and red beds which increase in number towards the top.

The coal content in the topmost upper Carboniferous series C_3^2 and C_3^3 is negligible; only rare, thin intercalations of coal and carbonaceous rocks occur. Argillaceous limestone beds are widespread and carry a shallow marine and brackish fauna, poor in generic content. The limestones have progressively higher $MgCO_3$ content towards the top.

Apparently, the sea became shallower at that period, dividing the Donets into closed and semiclosed basins, which made the deposition of magnesium carbonates possible. The climate probably was somewhat arid, which hampered the development of lush vegetation and led to the cessation of coal accumulation.

A survey of the facies content of Donets coal measures facilitated the identification of facies changes and of two highly individual types of coal accumulation, both connected with definite facies conditions: 1) coal accumulation on a flat seashore, sheltered by sand bars; 2) coal accumulation over a delta area with a migratory river mouth.

The present data on the coal measures of the

Karaganda, Kuznetsk, and Pechora Basins lead to the conclusion that whenever any of their component series is similar in facies composition to either of these two types of coal accumulation, that series also carries high grade coal beds, and is of great industrial interest.

When the suggested association of the facies and coal content is confirmed by more extensive material, the facies composition of the rocks may turn out to be one of the most important diagnostic features in the evaluation of little known coal-bearing areas and basins.

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CARBONATE CONCRETIONS IN THE MAYKOP DEPOSITS OF THE CENTRAL CIS-CAUCASUS

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INTRODUCTION

Carbonate concretions, particularly sideritic, are distributed throughout Carboniferous to Recent formations.

Sideritic concretions form iron ores, as exemplified by the Callovian clays of Lipetsk, the argillaceous Cimmerian-Pliocene deposits of Kerch and Taman, Jurassic deposits in the Sulak and Samur region of Daghestan, the Jurassic and upper Permian of the Vyatka-Vychegda watersheds, and the lower Carboniferous along the Kozhima river (Near-Polar Urals). Siderites and other carbonate concretions from the Maikop of the Central Cis-Caucasus have been noted but not studied.

The Maikop siderites are typical diagenetic formations and are useful in the study of diagenetic regularities and ore-body diagenesis.

Material composition, clarification of qualitative and quantitative relationships with enclosing rocks, and mapping the distribution of absolute mass were some of the problems involved. Well-cutting and cores from over 100 wells drilled in the Central Cis-Caucasus, into the upper, middle, and lower Maikop beds were examined, as were sideritic deposits along the Kugan, Bolshoi and Malyi Zelenchuk, and Urup rivers. The so-called absolute mass method was used in distribution studies; the number of carbonate formations is expressed in kilograms per cubic meter of matrix rock.

It is assumed that the thickness, as disclosed by drilling, is known. Then the volume of the core, geometrically a cylinder, is $V= \pi r^2 h$, where r is radius of the hole, and h is its height, i.e., the thickness of the upper Maikop. The overall volume of concretions is $V_{concr.} = \pi r^2 h'$, where h' is the overall concretion thickness (diameter nearly equal to hole). The average density is (V). The weight is, $P_{concr.}$ = Density/$V_{concr.}$ in kg.

In constructing the siderite areal distribution maps, the coefficient of concretization was used in addition to absolute carbonate mass data using A.V. Makedonov's method [5].

The Maikop concretions are gray, dark-gray, greenish-gray, and black in color as are the enclosing argillaceous rocks; when weathered they are encrusted by brown iron hydroxyls. The flat or lenslike concretions are layered; the round and elliptical types are markedly concentric. The existence of four groups are evident from chemical, mineral, and petrographic properties: 1) clay siderites, 2) clay-phosphate siderites, 3) clay ankerites, 4) clay calcites.

CLAY SIDERITES

The clay siderites are black, gray or dark gray. The fracture is uneven, shell-like or earthy. The low specific weight, 2.70-3.45 results from a fairly high insoluble residue (mostly clay).

Microscopically, the siderites are yellowish brown, yellowish gray, and greenish yellow in color. They are micrograined (less than 0.01 mm) and fine grained (0.01-0.1 mm), with 0.02-0.03 mm grains predominating. The siderite grains are diversified in form and closely interlocked with clay, clay-phosphate or opaline material filling the interstices. Irregularly distributed silt (1.0-5.0 percent) composed of semi-rounded grains of quartz, feldspar (0.01-0.04 mm), rare scales of sericite and chlorite is admixed).

Pyrite occurs in microconcretions (0.01-0.01 mm), lenticles or finely dispersed, and in the center of siderite grains. Iron hydroxyl results from oxidation of pyrite. Stratified siderite is caused by hydroxyl layering. Autogenous minerals include glauconite, rarely a lepto chlorite mineral (tabular grains, green, with cleavage and low double refraction), phosphates in microconcretions, bitumens, and rare grains of sphalerite and galenite. Secondary minerals, in fissures (septa), include calcite, pyrite and clay minerals; brown barite crystals (refraction index, Ng' = 1.610) were observed in botryoidal formations.

Table 1. Chemical analysis of argillaceous siderites.

Samples	Inorg. Res.	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	P_2O_5	CO_2	Total	Fe_{val}	S_{total}	S_{pyrite}	$S_{sulphate}$	$Ca_3(PO_4)_2$	CaO in apatite	$CaSO_4$
100-a	11,12	1,74	1,22	46,30	0,52	1,82	0,98	0,72	31,00	95,42	37,49	0,23	None	None	1,57	0,85	None
35-a	14,92	2,40	0,03	39,08	1,84	1,76	5,24	0,88	31,65	97,80	31,52	0,48	0,21	0,08	1,91	1,03	0,36
136-a	22,84	0,77	1,20	38,36	0,27	0,74	5,09	0,26	29,35	98,88	31,24	0,28	None	None	0,57	0,31	None
179-a	15,14	2,01	0,21	38,08	0,55	1,72	6,14	1,17	30,50	95,92	30,36	0,34	0,06	0,02	2,56	1,39	0,10
264	18,94	2,92	1,02	38,06	0,93	1,48	4,58	0,46	29,50	97,89	31,10	0,48	0,03	None	1,01	0,55	None
106-a	14,66	2,00	1,26	36,42	1,42	3,48	6,38	1,02	30,75	96,37	29,15	0,45	0,1—0,05	»	2,22	1,20	»
164-a	20,06	2,14	0,22	36,35	0,32	1,74	4,42	0,66	26,85	93,22	29,02	0,05	None	»	1,44	0,78	»
77	14,56	2,93	0,48	38,00	0,85	2,18	6,85	0,82	31,07	96,92	30,26	0,25	»	»	1,14	0,32	»
154-a	15,16	1,52	1,93	37,33	0,27	2,56	6,19	1,24	30,90	97,30	31,10	0,30	»	»	2,70	1,46	»
184-a	17,46	2,02	0,54	36,35	0,62	1,86	6,62	0,36	30,00	95,83	29,71	0,51	0,02	»	0,79	0,43	»
33-a	18,32	1,75	2,09	35,18	1,16	1,84	5,70	0,64	29,30	95,98	30,27	1,00	0,67	0,27	1,39	0,75	1,14
321	20,92	1,52	1,87	32,04	0,65	1,90	7,59	0,32	28,25	94,74	26,80	0,99	1,01	0,41	0,45	0,13	1,72
326	25,28	1,47	0,75	28,75	0,20	2,32	8,87	0,25	28,75	96,64	24,30	0,73	0,10	0,04	0,55	0,30	0,17
82	24,60	1,70	0,96	30,73	0,43	2,16	6,77	0,56	27,62	95,53	25,88	0,51	0,14	0,06	1,22	0,66	0,24
112	13,64	1,94	0,12	38,28	0,85	4,31	5,29	0,82	32,05	97,30	31,35	0,22	0,09	0,04	1,79	0,97	0,05
247	24,62	2,04	нет	30,56	0,32	2,13	8,05	0,43	27,82	95,97	25,39	1,06	None	None	0,94	0,51	None

Content of Ca, Mn, Fe, Mg carbonates in argillaceous siderites. (Table 1 continued)

Samples	Components						In % of total carbonates			
	$CaCO_3$	$MnCO_3$	$FeCO_3$	$MgCO_3$	MgO_{sil}	FeO_{sil}	$CaCO_3$	$MnCO_3$	$FeCO_3$	$MgCO_3$
100-a	1,73	0,84	73,75	2,10	0,68	None	2,20	1,08	94,07	2,65
35-a	1,30	2,98	63,80	10,47	None	»	1,65	3,80	81,21	13,34
136-a	0,17	0,44	61,75	10,68	0,17	»	1,04	0,60	83,85	14,51
179-a	0,59	0,89	61,24	12,73	0,10	0,06	0,78	1,19	81,16	16,87
264	1,68	1,51	61,38	9,06	0,12	0,26	2,20	1,97	80,38	15,45
106-a	4,07	2,30	57,14	12,20	1,00	0,55	5,37	3,04	75,47	16,12
164-a	1,71	0,52	56,65	7,38	1,56	0,89	2,61	0,77	85,36	11,26
77	3,89	1,38	58,41	12,13	1,74	1,13	5,13	1,83	77,05	15,99
154-a	1,96	0,43	60,54	13,24	None	None	2,57	0,56	79,48	17,39
184-a	2,55	1,00	56,84	12,37	0,60	0,40	3,50	1,37	78,10	17,03
33-a	1,10	1,87	57,17	12,10	0,28	0,18	1,52	2,59	79,14	16,75
321	1,87	1,05	51,68	14,83	None	0,13	2,69	1,51	74,43	21,37
326	3,60	0,32	49,36	17,77	0,63	0,16	5,06	0,45	68,06	26,43
82	2,67	0,69	49,53	14,14	0,01	None	3,83	1,02	73,89	21,26
112	5,96	1,38	61,30	10,76	0,26	0,14	7,63	1,75	78,46	12,16
247	2,89	0,52	47,76	15,74	0,54	0,94	4,32	0,80	71,38	23,50

Comma is equivalent to decimal point.

The chemical composition of siderites is more or less uniform (table 1). All specimens have a high content of insoluble residue, are low in ferric iron (Fe_2O_3 from 0.03 to 1.60 percent) - apparently a limonite component. A high phosphorous content (0.26-1.0 percent P_2O_5) is characteristic. Carbonates containing over 1.8 percent P_2O_5 are arbitrarily included in the clay-phosphate siderite group. The phosphorus content was calculated for apatite, $Ca_3(PO_4)_2$, although none was evident. The CaO and MnO content is low and nearly constant: MnO, 0.27 percent to 1.75 percent, CaO, 0.43 percent to 3.0 percent (CaO in calcium phosphate not considered). According to Dana [3], the maximum CaO content in siderites is 3.0 percent. Sulfur occurs as gypsum and pyrite. Gypsum is optically detectable as secondary mineral. Aluminum oxide apparently is a component of clay material.

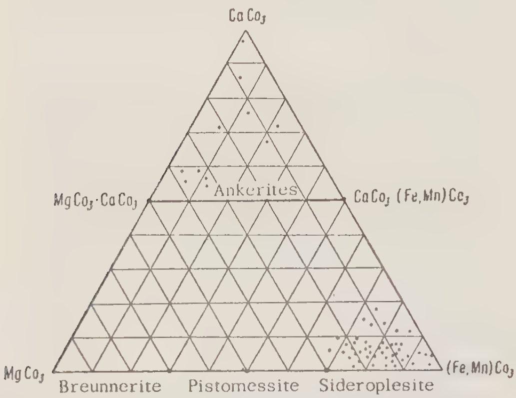

Fig. 1. Winchell's Diagram

The results of chemical analyses of HCl extraction were calculated for the carbonates.

As shown in table 1, the $MnCO_3$ content is fairly constant (average 2.4 percent); the refraction indices are similar to siderite indices, therefore $MnCO_3$ content is computed together with $FeCO_3$ [1].

The Maikop siderites are not purely iron compounds, but contain considerable $MgCO_3$ (5.0-24.0 percent) and are actually sideroplesites. Some specimens, however, contain 2.0-4.0 percent (specimen 100-a).

The refraction indices for clay siderites are Ng = 1.803-1.820, Np = 1.635-1.640. A graphic study of the molecular relation between $FeCO_3$ and $MgCO_3$, in siderites, has revealed an inverse ratio.

Thermal studies resulted in curves characteristic for siderite (fig. 3). An improved method of thermoanalysis, detecting as little as 1 percent ankerite, resulted in similar curves. X-ray analysis revealed that Mn, Ca, and Mg isomorphously replace Fe in the siderite lattice.

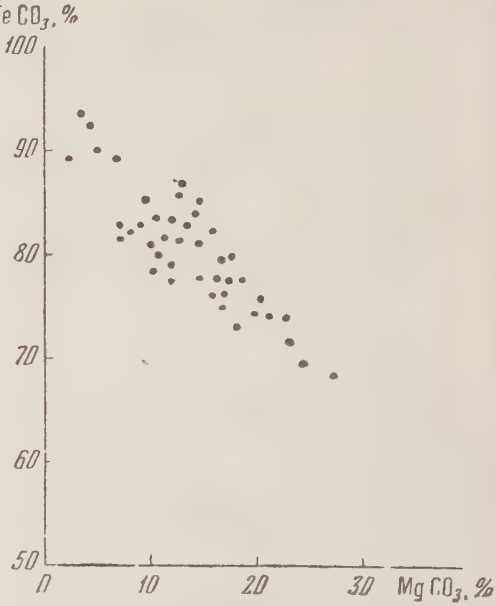

Fig. 2. Relation of $FeCO_3$ to $MgCO_3$ molecules in siderites.

Thus, Ca, Mg, and Mn carbonates, are present in the siderites and isomorphously replace Fe. Therefore, all carbonates of the siderites are in the same crystalline phase.

The siderites have massive, stratified, spotty, and reticulate microtextures. In the massive microtexture, the siderite grains are distributed without regularity, but are in close contact (fig. 4). The layered microtexture results from an alternation of grains, or from the layering of iron hydroxyls (fig. 5). Occasionally, grains in close contact form high density areas in the matrix. This distribution is typical for the spotty microtexture (fig. 6). In siderites with reticulate texture, tabular grains form a net (fig. 7). No relation between the textural and structural features of siderites, and their stratigraphic and facies characteristics has been established. Chemical and spectral analyses of the siderites established the presence of Cu, Ni, Co, Cr, V, Sr, and Ga (table 2).

The concentration of trace elements in the siderites is considerably lower than in the enclosing clays.

CLAY-PHOSPHATE SIDERITES

The clay-phosphate siderites contain from 1.0 to 8.0 percent P_2O_5 and differ from the clay siderites in certain respects.

Phosphatization is characteristic for the fine-grained varieties. The phosphate material

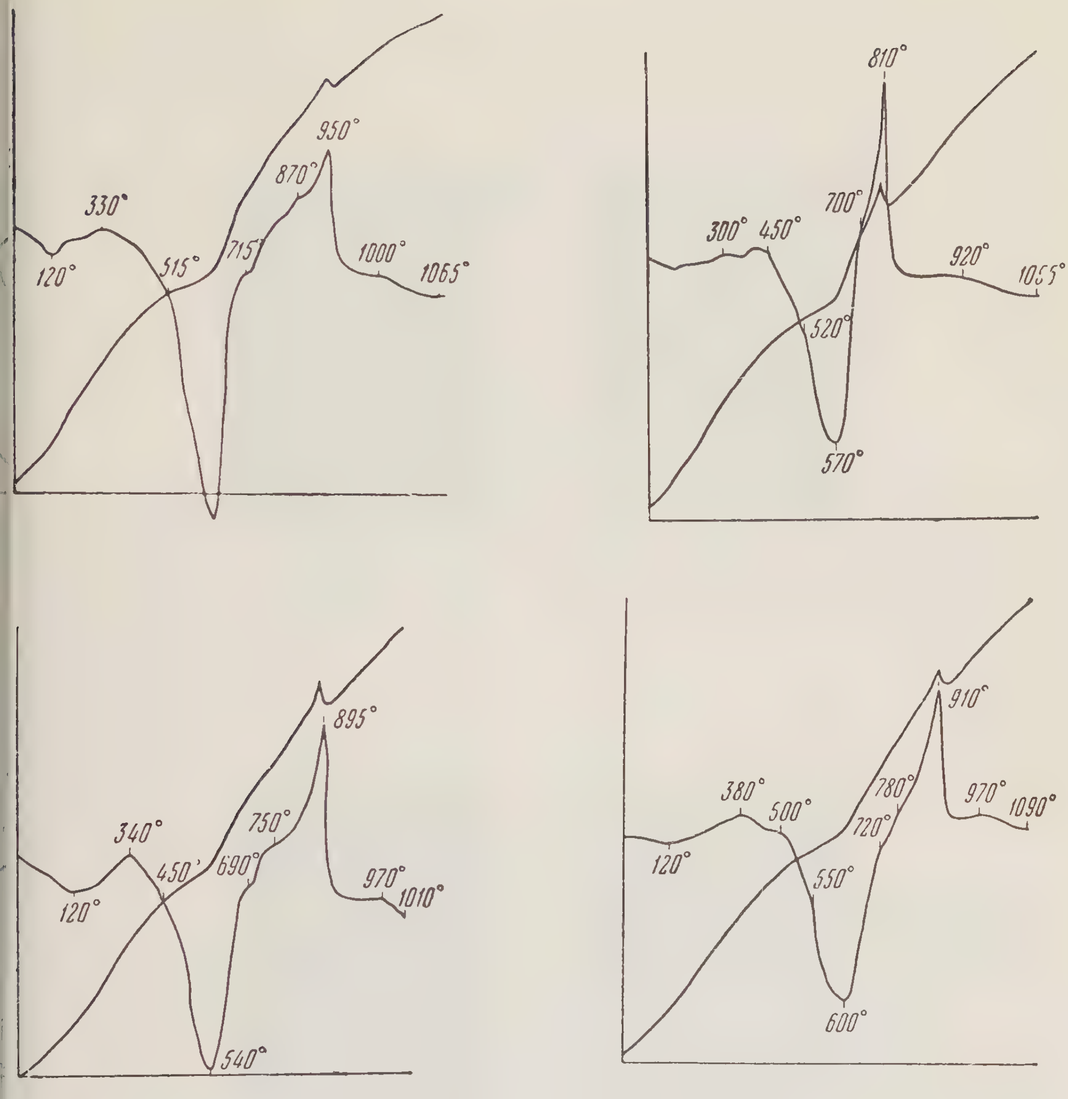

Fig. 3. Thermal curves for siderites

s seen to consist of colorless, yellow, brown, or drab calcium phosphate under the microscope, resembling iron hydroxyls. With two nicols, it is black and almost inactive to polarized light. Clay material and phosphate cement siderite grains. If the quantity of phosphate material is small, small spots and microbreccia form and are irregularly distributed. Phosphatized fragments of fish skeletons are common in the latter (Fig. 8). Double refraction for Ca is low (1.610-1.630).

The chemical composition of clay-phosphate siderites, and their Ca, Mg, Fe, Mn carbonates content are given in Table 3. The chemical composition is similar to that of the clay siderites, except that CaO and P_2O_5 content is higher in the latter.

CLAY-ANKERITE CONCRETIONS

Macroscopically, this concretion is similar to the siderites; the specific weight is 2.6-2.9. Microscopically, the ankerite grains have less relief and less sharply-defined surface granulation. The grains are diversified in form; spherolites occur.

Pyrite microconcretions are common, locally replacing floating glauconite grains; there are

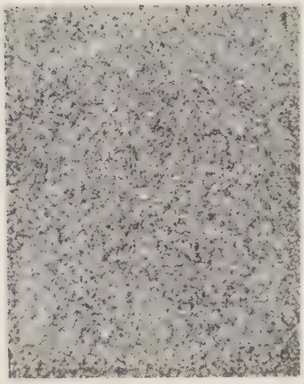

Fig. 4. Massive texture in siderite. Enlarged 40x, crossed nicols

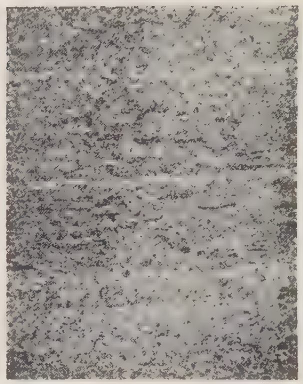

Fig. 5. Banded texture in siderite. Enlarged 40x, crossed nicols

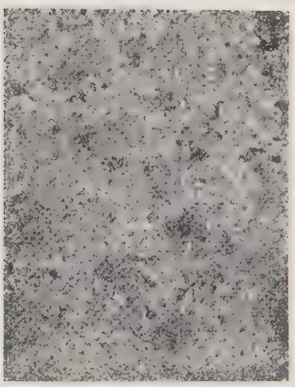

Fig. 6. Mottled texture in siderite. Enlarged 40x, crossed nicols

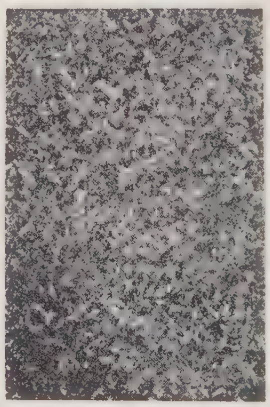

Fig. 7. Reticulate texture in siderite. Enlarged 40x, crossed nicols

occasional concretions and spots of calcium phosphate. Pulverized material is finely dispersed among the micrograined ankerites. There is considerable silt admixture, represented chiefly by quartz and feldspar grains, 0.01-0.04 mm in size. The latter, together with clay material, cement the ankerite grains. Here and there, the calcite and ankerite grains are replaced by calcite, which also (0.1 mm wide) cuts the ankerite concretions. Bituminous material and remains of fish skeletons occur. The texture is chiefly massive and, less commonly, layered.

The chemical analyses evidence considerable insoluble residue comparable to that of the siderites; ferric oxide content is low (0.16 0.75 percent). The P_2O_5 content is from 0.26 to 1.22 percent.

Table 2. Content of trace elements in carbonate concretions and surrounding rocks (in 10^{-3}% of the natural rock)

Elements	Upper Maykop		Middle Maykop		Lower Maykop	
	Carbonate concret.	Clay	Carbonate concret.	Clay	Carbonate concret.	Clay
Copper	2.0	5.0	2.0	6.0	1.4	5.1
Chromium	2.0	10.0	2.0	10.0	2.0	10.0
Nickel	2.0	7.1	1.9	8.0	3.0	6.6
Cobalt	0.2	2.0	0.2	1.0	0.5	1.0
Vanadium	5.0	14.0	4.0	20.0	5.0	14.0
Strontium	3.0	10.0	4.0	30.0	20.0	20.0
Beryllium	0.0	0.5	0.0	0.7	0.0	0.2
Molybdenum	0.0	10.0	0.0	0.4	0.0	0.1
Gallium	1.0	5.0	1.0	10.0	0.0	0.2

According to Dana [3], FeO in ankerite should exceed MgO. Some specimens show excess MgO. Thus, the presence of ferrous dolomite and magnesian ankerite apparently can be assumed. The first two components react like ankerites to all tests. Using the red blood salt (Isaenko) method establishes the presence of ankankerite with refraction indices, Ng = 1.692-1.702, Np = 1.512-1.690. Thermal studies show characteristic curves with three endothermic effects: at 700-730°C, 800-850°C, 890-920°C (Fig. 9). An endothermic effect is frequently observed here at 90-200°C, because of the clayey admixtures. A small endothermic effect at 350-500°C, due to pyrite, occurs as in the first two concretion types.

The weak endothermic effect at 730°C seems to result from pyrite which distorts the ankerite thermal curve (Sample 208). A. I. Tsvetkov's study has shown that pyrite may completely extinguish the first and second endothermic effects [7]. The same specimen contains calcite, which was determined optically. Specimen 33 (Fig. 9) probably contains a small amount of a mineral of the siderite-breinerite series besides the ferrous dolomite. According to Winchell's diagram, this mineral corresponds to mesitite (endothermic effect at 645°C and 650°C).

Ankerites, like the siderites, have four carbonate components; but, unlike the siderites, the latter not only isomorphically replace the calcite of the ankerite lattice, but are capable of forming their own crystalline phases. Thus, the ankerites frequently consist of two-three phases: ankerite, calcite, and rarely siderite-breinerite.

CLAY-CALCITE CONCRETION

This concretion type differs sharply from those described above, in its light-gray color, lesser hardness, and lower specific weight. Fissures (septa) filled with calcite and pyrite occur more often in calcitic concretions than in any others. Septate concretions are generally characteristic for this and the ankerite type.

Microscopically the calcite grains are predominantly oval or paw-shaped. The calcite matrix contains silt and clay admixture, some pyrite in microconcretions, and occasionally glauconite and phosphate material with refraction indices, Ng = 1.652-1.658, Np = 1.480-

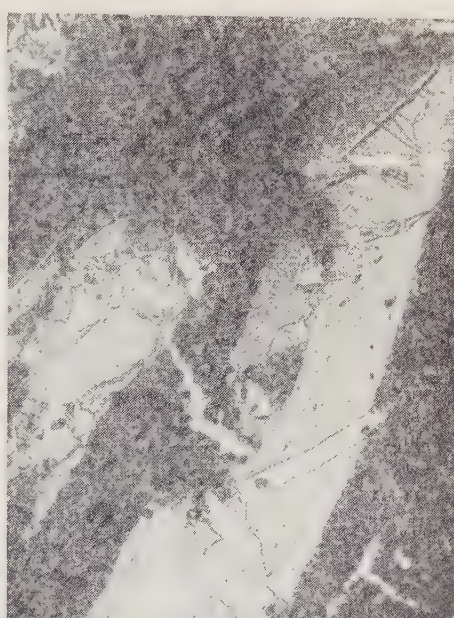

Fig. 8. Phosphatized fragments of fish skeletons in argillaceous siderites.

Table 3. Chemical analysis of argillaceous-phosphatic siderites

Samples	Components															
	Inorg. Res.	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	P_2O_5	CO_2	Total	Fe_{val}	S_{total}	S_{pyrite}	$S_{sulphate}$	$Ca_3(PO_4)_2$	CaO in apatite	$CaSO_4$
130-a	13,86	2,12	0,83	40,09	0,33	2,72	4,88	1,64	30,45	96,92	32,07	0,25	None	None	3,58	1,94	None
80-a	9,76	3,29	1,47	38,28	0,80	4,90	6,46	2,04	36,25	97,61	30,26	0,19	None	None	4,45	2,41	None
157-a	16,04	1,56	1,11	39,80	0,45	3,40	2,29	2,00	28,15	92,29	32,91	0.03	None	None	4,36	2,36	None
209-a	14,02	3,72	1,24	35,63	1,75	4,00	6,25	2,22	30,50	97,75	28,74	0,43	0,13	0,05	4,84	2,62	0,22
268	18,38	1,94	0,37	32,79	0,62	5,06	6,10	2,61	27,30	95,17	26,93	0,62	0,10	0,04	5,70	3,09	0,17
120	17,36	1,73	0,61	30,19	0,43	6,72	6,63	3,76	27,80	97,73	25,69	0,54	0,49	0,19	8,19	4,43	0,83
7	27,88	1,81	1,55	28,02	0,62	5,18	3,34	3,30	21,20	93.84	23,88	0,20	0,04	0,01	7,21	3,91	0,02
79	17,48	2,80	0,69	25,08	0.31	12,14	4,88	8,35	21,08	93,95	20,82	0,55	0,05	0,02	18,24	9,89	0,08
437	28,04	1,32	0,84	24,77	0,99	8,56	2,70	5,00	19,30	94,52	23,05	3,94	0,33	0,13	10,92	5,92	0,56
396	30,12	2,96	0,32	23.84	0,54	7,66	2,69	4,44	19,72	92,29	23,38	3,14	0,29	0,11	9,68	5,24	0,49
122-a	21,20	2,23	2,08	33,17	0,48	4,92	2,49	2,56	25,00	94,73	28,00	0,11	None	None	5,58	3,02	None
132	11,52	1,56	3,05	35,75	0,59	3,96	7,12	1,94	32,00	97,49	30,27	0,25	None	None	4,22	2,38	None
229	14,31	2,66	1,45	36,38	2,10	5,57	2,56	2,70	28,10	95,83	30,90	0,96	0,34	0,14	5,90	3,20	0,17
119	15,64	2,02	0,22	34,00	0,98	7,27	3,81	4,41	26,25	98,60	27,37	0,13	0,05	0,02	9,63	5,23	0,03
232	26,31	2,40	0,63	29,66	1,61	5,34	2,56	3,27	22,50	94,28	24,94	0,26	None	None	7,14	2,87	None

Content of Ca, Mn, Fe, Mg carbonates in argillaceous-phosphatic siderites

(Table 3 continued)

Samples	Components						In % of total carbonates			
	$CaCO_3$	$MnCO_3$	$FeCO_3$	$MgCO_3$	MgO_{sil}	FeO_{sil}	$CaCO_3$	$MnCO_3$	$FeCO_3$	$MgCO_3$
130-a	1,39	0,53	64,82	9,02	0,58	0,20	1,88	0,70	86,61	10,81
80-a	3,75	1,30	62,90	13,88	None	0,82	4,96	1,73	83,15	10,16
157-a	1,85	0,73	65,53	4,96	None	None	2,53	0,99	89,68	6,80
209-a	8,21	2,83	50,80	8,50	1,85	3,43	11,67	4,02	70,79	13,52
268	3,52	1,00	51,01	11,42	0,66	1,12	5.26	1,48	76,34	16,92
120	4,08	0,69	47,40	13,86	None	0,80	6,18	1,05	71,78	20,99
7	2,27	1,00	43,65	6,11	0,47	0,89	4,27	1,88	82,28	11,57
79	4,01	0,50	38.53	8,66	0,77	1,19	7,91	0,98	76,00	15,12
437	6,50	1,60	36,38	4,08	0,75	1,70	13,39	3,29	74,91	18,41
396	4,31	0,87	38,46	5,00	None	None	8,75	1,76	70,00	19,89
122-a	3,39	0,77	50,76	5,96	None	3,12	5,00	1,13	74,97	18,72
132	2,99	0,95	58,51	15,51	None	0,54	3,86	1,23	75,01	19,90
229	4,29	3,40	59,13	5,24	None	None	5,87	4,72	82,12	7,29
119	3,66	1,59	53,56	7,08	0,41	0,78	5,55	2,41	81,28	10,76
232	2,62	2,61	48,34	4,78	None	None	4,47	4,47	82,84	8,22

Comma is equivalent to decimal point.

Table 4. Chemical analysis of argillaceous ankerites and calcites

Samples	Components															
	Inorg. Res.	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	P_2O_5	CO_2	Total	Fe_{val}	S_{total}	S_{pyrite}	$S_{sulphate}$	$Ca_3(PO_4)_2$	CaO in apatite	$CaSO_4$
203	12,72	0,81	0,16	3,42	0,28	26,68	14,82	0,12	38,05	97,06	3,44	0,55	0,20	0,09	0,26	0,14	0,38
201	13,84	0,35	0,16	3,93	0,22	26,08	12,18	0,56	35,95	93,25	3,81	0,48	0,20	0,08	1,22	0,66	0,24
133	17,79	0,89	0,64	5,39	4,66	29,66	2,53	2,45	28,90	92,91	6,29	1,38	0,06	0,16	5,35	2,90	0,10
207	28,80	1,24	0,15	4,80	0,10	27,94	4,17	0,42	28,25	95,87	5,16	1,11	0.10	0,24	0,92	0,50	0,15
209	25,95	0,68	0,38	4,66	0,07	22,14	10,86	0,61	31,30	96,65	4,81	0,91	0,05	0,13	1,33	0,72	0,08
211	20,12	0,75	None	4,51	0,07	24,90	10,96	0,69	34,00	96,00	4,58	0,83	0,05	0,12	1,51	0,82	0,08
200	9,09	0,30	None	2,92	0,19	28,29	16,05	0,48	41,15	98,47	2,65	0,33	0,03	0,07	1,05	0,57	0,05
208	24,80	1,57	1,69	3,20	0,10	27,10	7,04	0,09	30,65	96,24	4,97	0,98	0,12	0,08	0,20	0,11	0,30
199	9,08	0,92	0,64	11,14	0,90	32,00	5,74	0,58	37,15	98,17	9,72	0,59	0,14	0,05	0,83	0,25	0,24
203-a	19,56	0,03	0,81	2,15	0,36	35,96	3,63	1,42	31,96	95,98	3,23	0,97	0,23	0,09	3,09	1,67	0,40
491	8,50	0,20	0,31	0,17	0,40	46,95	2,23	0,16	38,70	98,42	1,05	0,54	0,66	0,26	0,35	0,19	1,12

Content of Ca, Mn, Fe, Mg carbonates in argillaceous ankerites and calcites (Table 4 continued)

Samples	Components						Components in % of total carbonates			
	$CaCO_3$	$MnCO_3$	$FeCO_3$	$MgCO_3$	MgO_{sil}	FeO_{sil}	$CaCO_3$	$MnCO_3$	$FeCO_3$	$MgCO_3$
203	47,36	0,45	3,91	29,85	0,55	0,99	58,10	0,55	4,80	36,55
201	45,33	0,36	6,34	25,47	None	None	58.50	0,46	8,20	32,84
133	47,76	7,55	7,87	4,06	None	0,50	71.03	11,22	11,70	6,05
207	48.97	0,16	6,65	7,93	0,38	0,68	76,88	0,25	10,43	12,44
209	38,23	0,11	7,46	22,47	0,12	None	56,00	0,16	10,92	32,92
211	42,97	0,11	7,73	23,25	None	None	58,02	0,14	10,43	31,51
200	49,47	0.31	4,63	33,54	0,01	None	56,24	0,85	5.26	38,15
208	48,17	0,16	5,16	14,31	0,10	None	71,05	0.23	7,61	21,11
199	57,12	1,46	15.90	10,79	0,58	1,36	66,98	1,71	18,64	12,67
203-a	61,19	0,58	3,88	7,01	1,44	None	84,21	0,78	5,33	9,68
491	82,63	None	None	4,49	0,33	None	97,14	None	None	2,86

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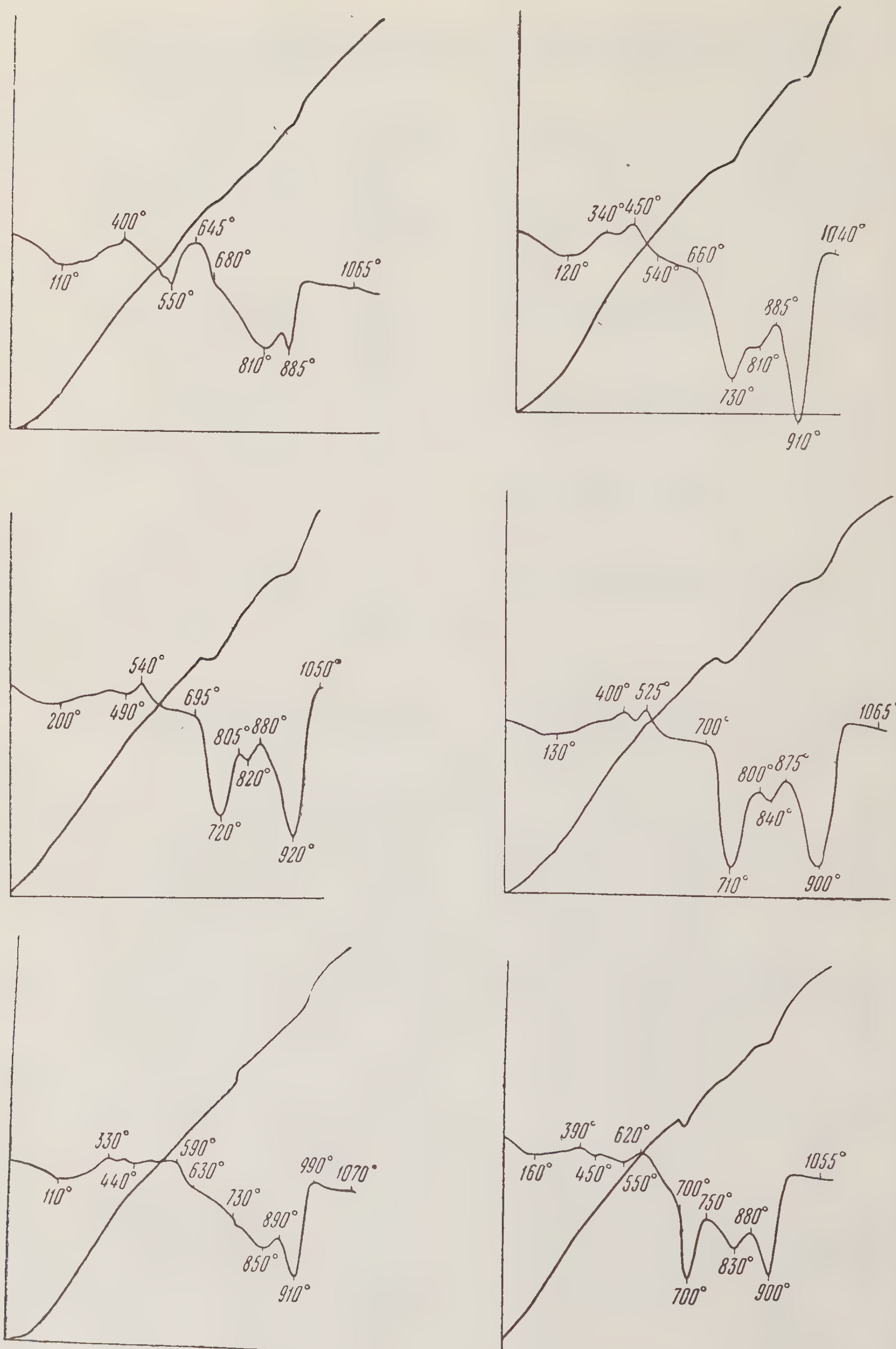

Fig. 9. Thermal curves for ankerites

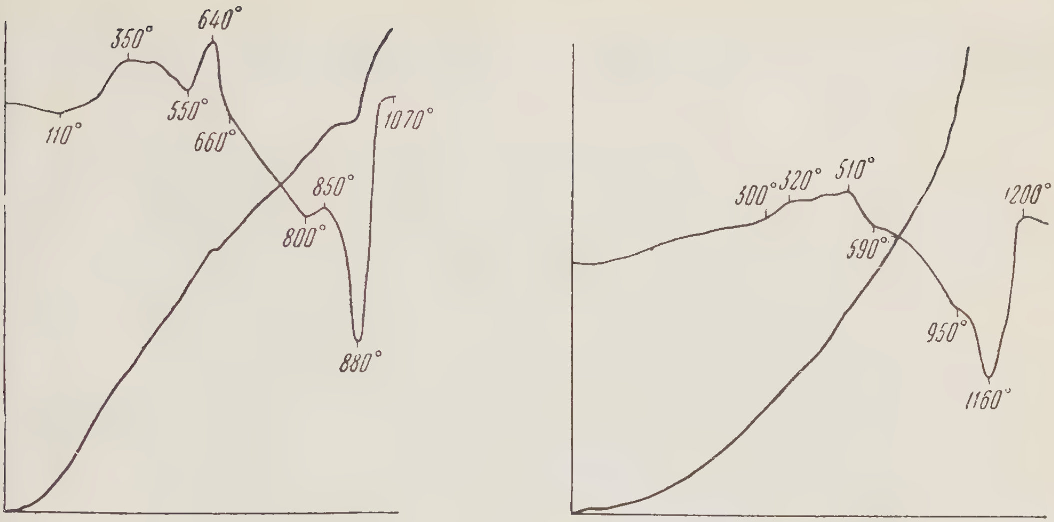

Fig. 10. Thermal curves for calcites.

1.486. The chemical composition of calcites is given in Table 4.

Thermal studies give typical calcite curves (Fig. 10). Besides the basic mineral - calcite - this type of concretions often contains ankerite which can be determined optically, by dyes, and by thermal analysis. The thermal curve (Fig. 10) for specimen 203 suggests the presence of ankerite. Two endothermic peaks are distinct: at 800°C and 880°C. The third endothermic peak, that of ankerite, is lacking in this curve. Thermal studies by D. A. Vital on artificial mixtures have shown that the third endothermic peak may not materialize if some calcite is present (2). It is possible that specimen 203 contains some pistomesite (endothermic peak at 550°C, exothermic peak at 640°C). Thus two-three phases exist: calcite, ankerite, and possibly a third - siderite-breinerite.

The most common concretions are the clay-sideritic and clay-phosphate siderites. They occur throughout the Maikop section; the ankeritic and calcitic concretions are observed only at the base of the upper Maikop and in the lower Maikop, where thin argillaceous limes are interbedded with non-calcareous argillaceous deposits.

ENCLOSING ROCKS

Clays with occasional intercalations of siltstones and sandstones enclose the carbonate concretions.

Several mineralogical types occur in the clays; hydromicas with kaolinite, montmorillonitic, beidellitic, hydromicaceous, and hydromicaceous-beidellitic types alternate periodically. Finely dispersed clays predominate in beidellites and montmorillonites, and sandy-silty clays in the hydromicaceous rocks. The sandy-silty fraction of the clays contains heavy and light minerals. The heavy fraction includes the magnetite group, ilmenite, pyroxenes, epidote, and the disthene-staurolite group, sillimanite. The light fraction consists of quartz, feldspars, muscovite, glauconite, and dark pellitic crumbs. Diagenetic minerals such as siderite, pyrite, glauconite, calcite, and phosphates of calcium occur in fair amounts. The montmorillonitic and beidellitic clays contain siderite, pyrite, calcium phosphate, bitumens, and rarely glauconite. Glauconite and calcite are most common in the hydromicaceous clays.

The Maikop clays are almost lime-free; their overall carbonate content is 0-2.0 percent. The lower Maikop deposits, however, carry thin calcareous clays, with an overall carbonate content of 30 percent. Similar calcareous layers (2-3) occur in the lower middle Maikop (Septarian series). The clays are usually thin-bedded, less commonly they have a broken texture.

The sandstones and siltstones consist of well- and semi-rounded grains of quartz and feldspar. Small amounts of the minerals previously mentioned occur in the sandy-silty clay fraction. The cement composition is diversified: clayey-kaolinized, opal or carbonate. Cementation is basal or mixed.

The distribution of sediments and carbonate concretions in Central Cis-Caucasus area differs with different periods.

In the south the lower Maikop (Nevinnomyssk, Yankul, Surkul) is composed of finely dispersed clays. Northward, in the Stavropol area clays with numerous thin layers of fine-grained sand and fairly thick silt beds occur. In the North Stavropol area, the sand content increases

sharply. Horizons up to 30 m thick occur here and farther to the north. An increase in sand content is also observed west of the Nevinnomyssk area. In the Budennovsk area, east of the to 0-6 kg/m (concretization coefficient, 0-0.2 percent). In the North Stavropol area, the sand content of the clays increases sharply, and concretions are rare. The concretization coeffi-

Fig. 11. Distribution of carbonate concretions in the lower Maykop. Scale 1:1,750,000. Compiled by Yu. A. Pryakhina.

1 - sandy clays with thick alternating layers of sand and siltstone; do not contain any carbonate concretions; 2 - clays with few layers of sand and siltstone, with a concretion coefficient of 0-0.2% (absolute mass of concretions 0-6 kg/m^3); 3 - finely dispersed clays with a concretion coefficient of 0.2-0.4% (absolute mass of concretions 6-16 kg/m^3); 4 - bore holes, locating the lower Maykop formations; 5 - contacts of the lower Maykop formation.

Yankul, drilling has disclosed that the lower Maikop is composed of sandy-silty clays with numerous siltstone intercalations. These deposits are the thickest in the south.

All four types of carbonate concretions occur in the lower Maikop deposits. The map (Fig. 11) shows the distribution of absolute masses (kg/M^3) in the lower Maikop deposits. The concretization coefficient is also indicated. The absolute masses vary from 0 to 16 kg/m^3, the concretization coefficient, from 0 to 0.4 percent. As shown on the map, the maximum concentration of absolute mass occurs in the south, where finely dispersed clays are developed (6-16 kg/m^3, or a concretization coefficient of 0.2-0.4 percent). North, in the Senghilei-Stavropol area clays with layers of sand and siltstones occur and the concentration of absolute masses drops

cient is zero. East of the Yankul and west of the Nevinnomyssk, it is 0-0.2 percent.

Thus, the content of carbonate concretions in clays increases with sand content, reaching its maximum in the finely dispersed clays.

Sediment distribution changes somewhat in the Middle Maikop. These deposits are the thickest in Yankul, Surkul, and Nevinnomyssk. They are composed of finely dispersed clays. South, in the Zelenchuk series of the Middle Maikop, bedded sandstones, which are often lenticular and up to 1 m in thickness, are observed along the Kuban river. West of the Kuban, along the Bol'shoy Zelenchuk river, an increase in the number of fine-grained sand and silt intercalations is noted, as is an increase in thickness of characteristic sand beds and lenses. To the east and north, the Zelenchuk sandstones

rapidly wedge out. In the Nagutskoye area (southeast of Yankul) only thin layers of tight, fine-grained sandstones occur. No sandstones have been found in the Nevinnomyssk area or the northern part of Stavropol. Still farther north, however, in the Ivanovskoye wells and in well P-1 Sharbuluk, siltstones and fine-grained sandstone appear in the clays.

Thus, two regions of sand deposits are noted: the northern and the southern. In the opinion of field workers, these regions are not connected. The middle Maykop sands came from the Main Caucasus ridge, in the south and from the Russian platform, in the north [4].

Only siderite-breinerite concretions (sideroplesites) have been noted in the middle Maykop, with the exception of three-four concretionary layers of calcite and ankerite composition, at the base of the middle Maykop (Septarian series).

Figure 12 is a distribution map for absolute masses of siderite in the middle Maykop deposits. It shows that the absolute masses of the siderite concretions vary strongly from place to place. The variation intervals are:

Absolute masses in kg/m^3	Concretization coefficient in %
0- 6.0	0-0.2
6.0-16.0	0.2-0.4
16.0-23.0	0.4-0.7
23.0-28.0	0.7-1.0

Maximum values for the concretization coefficient correspond to areas of development of finely-dispersed clay formations. Nevinnomyssk, Surkul, and Yankul localities comprise one area. The other area is northwest of Stavropol. Minimum siderite concentration is observed north of the north Stavropol area where the clays contain sandy-silty horizons, and south of the southern belt finely-argillaceous formations. The concretization coefficient varies from 0 to 0.2 percent. There is a small area with the minimum concretization coefficient in the center of the Stavropol locality. The deposits are represented here by argillaceous formations. Thus, the locality is divided into two distinct sections: the northern and the southern.

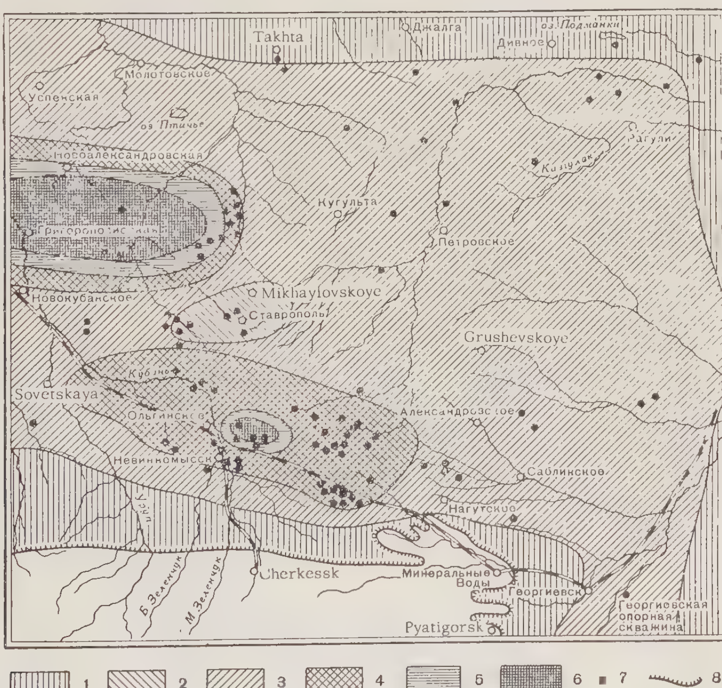

Fig. 12. Distribution of carbonate concretions (siderites) in the middle Maykop formation. Scale: 1,750,000. Compiled by Yu. A. Pryakhina.

1 - clays with few layers of sand and siltstone, the concretion coefficient is 0-0.2% (absolute mass of concretions is 0-6 kg/m^3); 2 - finely dispersed clays with a concretion coefficient of 0-0.2% (absolute mass of concretions is 0-6 kg/m^3); 3 - finely dispersed clays with a concretion coefficient of 0.2-0.4% (absolute mass of concretions is 6-16 kg/m^3); 4 - finely dispersed clays with a concretion coefficient of 0.4-0.7% (absolute mass of concretions is 16-23 kg/m^3); 5 - finely dispersed clays with a concretion coefficient of 0.7-1% (absolute mass of concretions is 23-28 kg/m^3); 6 - finely dispersed clay with a concretion coefficient greater than 1% (absolute mass of concretion is 28 kg/m^3); 7 - bore holes, locating the middle Maykop formations; 8 - contacts of the middle Maykop formation.

The distribution of carbonate concretions in the middle Maikop is similar to that in the lower Maikop. It shows that the main body of siderites gravitates toward the argillaceous sediments. The same is true in the upper Maikop.

In upper Maikop time, the distribution of argillaceous and areno-argillaceous deposits changes radically. Only the argillaceous deposits are developed in the southern belt of the Central Cis-Caucasus; sandy deposits occur to the east. Thus, northeast of the Yankul area, a formation composed of 30-40 m of alternating clays and fine-grained sandstones occurs in the upper Maikop argillaceous deposits. Northward, in the Ipatovo, Takhta and Kuguta areas, the upper Maikop penetrated by drilling were also sandy. But in the Ivanovo area (northern of north Stavropol) there is practically no sand in the clays.

Only sideritic concretions (sideroplesites) have been noted in the upper Maikop deposits. Figure 13 shows the distribution map for siderite concretions. The variation intervals for the absolute mass of concretions are the same as for the middle Maikop. The maximum concentrations of siderites occur in the zone of fine sediments (Surkul, Yakul, Nevinnomyssk, and Kamennobrodskaya areas); the eastern zone of areno-argillaceous formations, and the northern zone, show the minimum siderite concentration (0-6 kg/m^3, or concretization coefficient of 0-0.2 percent).

On all three maps of the concretion distribution in the Maikop the main body of carbonate concretions is concentrated from Nevinnomyssk to Kruglolesskoya. To the north, their thickness decreases sharply. In the southern area where well-sorted clays were deposited, the distribution of carbonate concretions is spotty (middle and upper Maikop), apparently a result of differential downwarping during the Maikop time, and correspondingly different diagenetic processes.

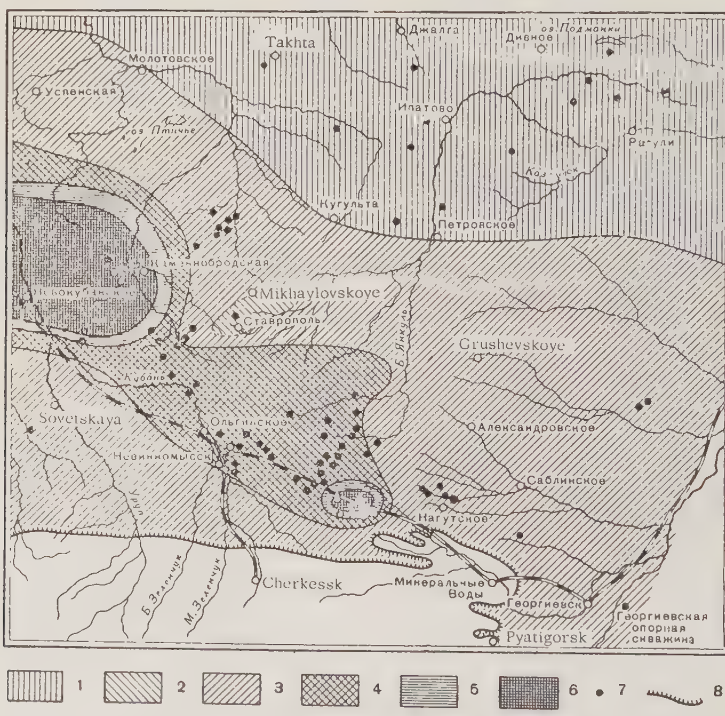

Fig. 13. Distribution of carbonate concretions (siderites) in the upper Maykop formation. Scale: 1:1,750,000. Compiled by Yu. A. Pryakhina.

1 - clays with few layers of sand and siltstone, the concretion coefficient is 0-0.2% (absolute mass of concretions is 0-6 kg/m^3); 2 - finely dispersed clays with a concretion coefficient of 0-0.2% (absolute mass of concretions 0-6 kg/m^3); 3 - finely dispersed clays with a concretion coefficient of 0.2-0.4% (absolute mass of concretions is 6-16 kg/m^3); 4 - finely dispersed clays with a concretion coefficient of 0.4-0.7% (absolute mass of concretions is 16-23 kg/m^3); 5 - finely dispersed clays with a concretion coefficient of 0.7-1.0% (absolute mass of concretions is 23-28 kg/m^3); 6 - finely dispersed clays with a concretion coefficient greater than 1.0% (absolute mass of concretions is 28 kg/m); 7 - bore holes, locating the upper Maykop formation; 8 - contacts of the upper Maykop formation.

GENESIS OF THE MAIKOP CARBONATE CONCRETIONS

Deposition of sediments with carbonate concretions occurred in marine conditions [4]. The presence of organic matter (bitumens, carbonaceous fragments, etc.), pyrite, and siderite indicates a reducing environment. The periodical and multiple alternation of clay types, the presence of carbonate concretions differing in composition, and a lack of uniformity in distribution were brought about partly by a change in hydrochemical conditions during deposition but chiefly by differential processes during diagenesis.

The formation of carbonate concretions is related to redistribution of material in diagenesis. N.M. Strakhov [6].

The formation of siderite concretions occurs when lime is unavailable. Under such conditions, the pH is low, CO_2 concentration is raised, an intensive redistribution of $FeCO_3$ takes place, and siderite concretions are formed. The large amount of $MgCO_3$ in siderites is anomalous for a normal marine basin. The formation of $MgCO_3$ is connected with desulfatization processes in the oozes, under reducing conditions [6]. The source of iron in incipient and growing concretions was the clay sediments. The overall iron content in the original sediment, as calculated prior to the formation of concretions, did not exceed the natural average (Clarke). Even in the area (Surkul) where clays are strongly saturated by siderites the overall Fe content (Fe_{val} of the tables) prior to siderite formation was 5-9 percent, only slightly above the natural average. Thus, the formation of siderite concretions does not require any higher than average iron content in the mother rock.

The formation of calcite and ankerite concretions in locally calcareous clays is related to the increase of pH and the decrease of CO_2 concentration which prompts calcite migration.

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ON THE GENESIS OF IRON ORE DEPOSITS IN SOUTH YAKUTIA

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ABSTRACT

The main features of the geological structure and composition of the rocks and ores of the southern Yakutian iron-ore deposits, including complex boron-iron ores, are described. Existing opinions on conditions of formation of these deposits are critically examined. The arguments of the adherents of a sedimentary-metamorphic origin of iron concentration are refuted, and the ores are shown to be skarns.

The tendency to revise the genesis of some deposits of various useful minerals which have been unanimously accepted as being of magmatic origin has been widespread. The formation of these deposits is thought to be due to regional (or contact-regional) metamorphism of sediments containing primary concentrations. When proved by objective data to be correct in its relation to individual deposits, this solution, with absolutely no justification, was extended to a large number of other deposits. The weakness of the arguments and hasty conclusions drawn by some investigators in representing many magmatic deposits as sedimentary-metamorphic is not always apparent to those unacquainted with the actual deposits. Thus, a broader basis of discussion of the main arguments for the sedimentary-metamorphic hypothesis in relation to actual large-scale and typical deposits is necessary.

The southern Yakutian iron deposits in the Archean crystalline complex of the Aldan shield have no analogues among other iron ore deposits in the U.S.S.R. The problem of the genesis of these deposits has been discussed recently in papers by D. S. Korzhinsky [7], N. G. Sudovikov and M. D. Krylova [19], L. I. Shabynin [21-25], A. A. Marakushev [11], and D. P. Serdyuchenko [13-17].

The following three viewpoints have been expressed: 1) the deposits are contact metasomatic [7, 21-25]; 2) the ore bodies have formed as a result of regional metamorphism of sediments rich in iron, and, in places, boron; metasomatic processes only were responsible in some parts for a local movement of iron and boron [13-17]; 3) the iron ores and lime-magnesium and magnesium rocks enclosing them originated as the result of regional metasomatic replacement of Archean rocks, due to loss of calcium, magnesium, and iron from the zone of granitization into the overlying parts of the structure [19].

In this paper an attempt is made: a) to demonstrate the agreements and disparities between data based on facts obtained during a protracted study of the southern Yakutian deposits and the main positions of the above three points of view on the genesis of these deposits; b) to remove as far as possible some serious inaccuracies in describing features of these deposits which, it is to be regretfully stated, occur in parts of published papers.

The southern Yakutian iron deposits in the form four natural territorial groups. To the southwest group belong the Piricherskoye, Levo, and Pravo-Desovskoye iron ore deposits; in the south, the Siraglinskoye (Sivagla) Pionerskoye, and Komsomol'skoye; in the north and northwest, the Yemd'dzhakskiye iron ore (and phlogopite iron ores) and the Tsentral'no-Aldanskiye (central Aldan) iron ores; and finally, in the southeastern group, the Tayezhnoye, Magnetitovoye, Legliyerskoye, and Tinskoye deposits.

The bulk of these deposits are located in the crystalline schists of the Federov suite of the lower Iyengrskaia series of the Archean of the Aldan shield; the northern group is referred to the upper Dzheltulinskaya series (according to the unpublished data of Litsarev), but the central Aldan deposits conform to the contacts of Mesozoic syenite-porphyries with Cambrian dolomites.

All these iron ore deposits are of one type in their genetic relationships, general geologic location (at the contact of dolomites and alumino-silicate rocks). The mineral composition

of the ores and skarns is the same, although stratigraphically they enter into very different complexes. In parts of them, combined deposits of phlogopite and magnetite occur regularly (Yemd'dzhak, Tayezhnoye).

The following rock types characterize the general structure of the deposits: granitized pyroxene, biotite or hornblende gneisses and feldspathic schists, alaskite granites; dolomite marbles and calciphyres; olivine, pyroxene, mica, sometimes hornblende rocks (skarns); magnetite ores with a certain amount of silicates; also scapolite (mainly diopside-scapolite) rocks; and sometimes pyroxene-andradite skarns.

The most characteristic feature of the deposits is distinct metasomatic zoning. Skarns, free of micaceous constituents, are represented by massive coarse-grained rocks, usually almost monomineralic. The boundaries between the separate zones are usually sharp. The separate zones, when combined, form a metasomatic column; the mineral assemblage and the situation of each zone is precisely controlled. The zoning is clearly shown, not only in sections through the deposit, but also in separately taken samples (figs. 1 and 2). The following persistent order of arrangement is observed (from dolomites to alumino-silicate rocks): 1) dolomite marble (or calciphyre); 2) olivine skarn (± spinel, diopside, and phlogopite) more or less replaced by dinohumite or serpentine; 3) diopside or hypersthene skarn (±spinel, phlogopite, and pargasite); 4) phlogopite skarn (± pyroxene); 5) hornblende skarn; 6) host rocks to the skarns (pyroxene feldspar or pyroxene scapolite) rocks; 7) migmatitic schist, gneiss, or alaskite.

A detailed study and theoretical analysis of the mineral paragenesis of the ores, skarns, and skarnlike rocks shows that the persistent differences in the structures of the cores, which are true of all the deposits in a region, are caused by different stages of skarn formation (magmatic or postmagmatic), and by the differences in alkalinity, iron content, and other features of the solutions and also in the composition of the original rock.

The zoning does not depend on the stratigraphic position of the dolomite beds and is seen in deposits of a region enclosed in both the lower and upper parts an Archean section and in Cambrian dolomites (in contact with syenite porphyries).

Complete interdependence in the development of skarns and skarnlike rocks can be demonstrated. In particular, postmagmatic alterations of feldspathic rocks enclosing the skarns expressed as the replacement of feldspars by scapolite and the development of diopside in the rock, originates in these rocks only at their contacts with dolomites and only in conjunction with and synchronously, the replacement of the latter by silicates. Both these processes are of the same intensity and are detected in all stages of development. They are visually demonstrated when observed along the same contact of dolomite marbles with an alumino-silicate rock.

The mineral assemblages and the positions of the zones in a postmagmatic core which is typical of the iron ore deposits of a region, are analogous to those observed in phlogopite deposits which are considered to be classic examples of contact-metasomatic deposits [7]. In the Tayezhnoye and Yemel'dzhakskoye deposits, the "pay zones" of phlogopite and iron mineralization are situated within one portion of the contact of migmatite gneisses with dolomite marbles.

The zoning of the southern Yakutian iron-ore deposits is analogous in every respect to zoning in the contacts of intrusive granitoids with dolomites of different ages, in a whole series of different contact-metasomatic ore deposits. The main differences are the thickness of the individual zones and the composition of minerals of variable composition (iron in olivines, pyroxenes, micas, amphiboles, the basicity of scapolites).

The interrelationships of ores and skarns with the granites of the southern Yakutian deposits are controlled by the following factors:

1. Skarn formation and ore replacement not only of the rocks enclosing the skarns and the schists but also of the migmatite gneisses and true alaskite granites are widespread.

2. The complex of crystalline schists and gneisses enclosing the skarn-ore masses are granitized and abound in isolated masses of various sizes and shapes, and injections of alaskite granite material. Fine lenticular layers of the above-mentioned rocks enclosed in thick masses of calciphyres, ores and skarns; injection of granitic material into the apodolomites, in particular into what are essentially olivine (serpentine) skarns and ores has not been observed. However small the mass of any seam of alumino-silicate rock in these skarns or ores, the granitic material is completely limited by the extent of the seam and is not found in the skarn or the ore; there is a sharply different situation as regards the formation of the granite apodolomites and skarns and ores, and the rocks enclosing them. Both skarns and ores, as well as their enclosing rocks, occupy a similar position with regard to Mesozoic syenite porphyries, for example they are cut by them, and occur as xènoliths in them, and so forth.

No signs of metamorphism of iron ores have

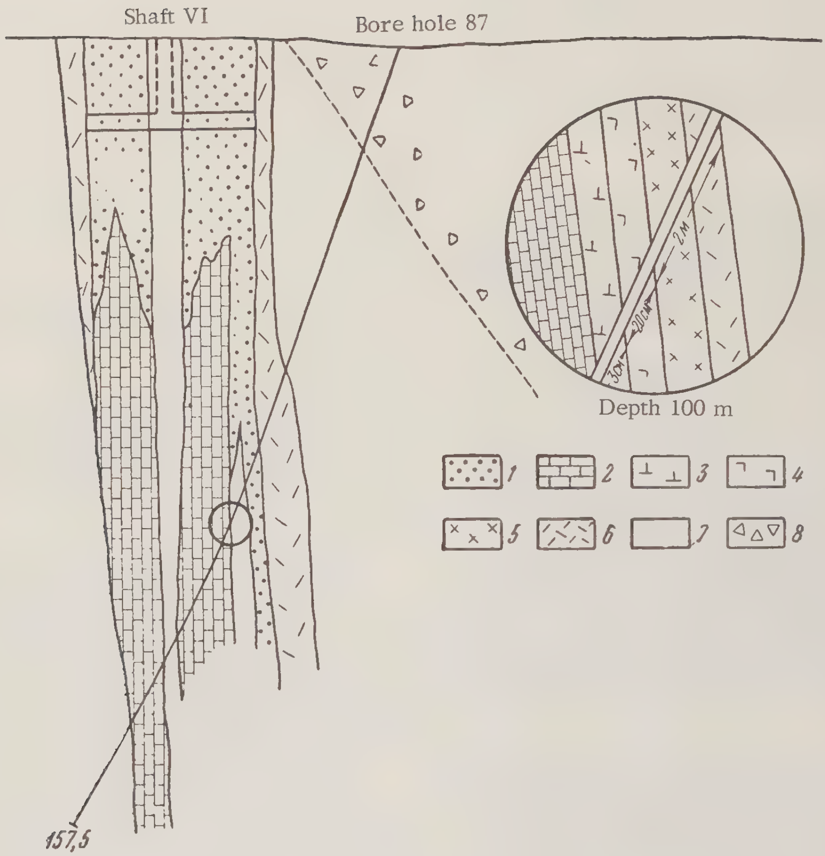

Fig. 1. Geological section of the Tayezhnoye deposit, along bore hole 87 (after A.A. Marakushev).

The ore body is replaced with depth by a dolomitic calciphyre. A reaction zone developed at the contact of the latter with migmatitic crystalline schists and gneisses (details of the contact are shown in the inset).
1 - serpentine-magnetite ore; 2 - calciphyre; 3 - olivine (serpentinized) skarn; 4 - diopside skarn; 5 - phlogopite skarn (with diopside), with remnants of plagioclase; 6 - diopside-plagioclase skarn-like rock; 7 - migmatized crystalline schists and gneisses; 8 - tectonic breccia.

been observed. In the rocks surrounding the skarns, which have developed in place from granitized schists and gneisses, the granitic material is partially preserved in places and occurs as isolated relict patches in the rock.

3. In individual deposits, mineralization occurs in andradite-salite-skarns formed from lime-carbonate rocks (Nirichi, Pravyi Des).

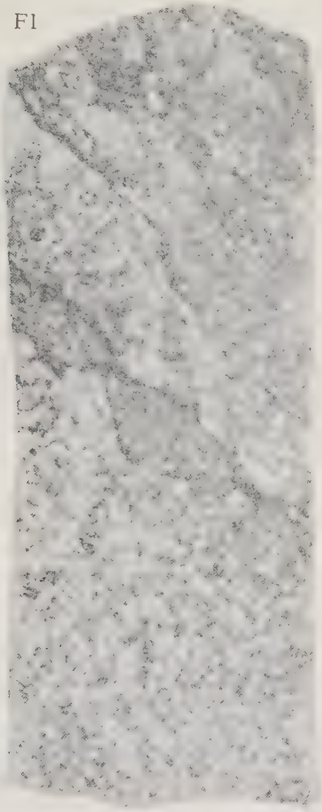

Fig. 2. Metasomatic zonation in ore sample.

Ka - dolomitic-calcic rock, Sp - olivine zone, Di - diopside zone, Fl - phlogopite zone (Tayezhnoye, bore hole 42) $\frac{1}{2}$ natural size.

A characteristic feature of these ores and skarns is the presence of rare injections of granitic material unaccompanied by reaction of the zones in contact with the skarns. This is a consequence of injections into andradite-salite skarns earlier formed, and not into carbonate rocks. These skarns and ores are evidently related to the magmatic stage of formation. Such (magmatic stage) skarns are frequent in skarn-ore deposits (see, for example, [5]).

Skarns of the magmatic stage and dolomite ores are of significance in only a few deposits of the region. They are represented by variation in hypersthene and feldspars. There is no injection of granitic material in these skarns and ores, but a high-temperature replacement of magmetite by green spinel takes place.

Magnetite mineralization in exoskarns after dolomites is concentrated almost exclusively in the zone of olivine (and olivine-phlogopite-olivine) skarn and also in places where diopside endoskarns are strongly developed. The mineral parageneses of the magnetite ores of the main (high-temperature) stage in the southern Yakutian deposits are of one type. Among them must be distinguished ore parageneses: a) in magnesian skarns after dolomites and b) ore replacement of the host rocks of the skarns, granites converted into skarns (skarn granites) and migmatized schists and gneisses.

Serpentine-magnetite ores are the most widespread of the first group. Ores which are essentially phlogopite and contain variable amounts of serpentine and, comparatively rarely, olivine-hypersthene (sometimes with diopside) magnetite ores, occur. The relations of magnetite and other minerals show that crystallization began almost at the same time as that of olivine and continued with the replacement of the latter.

The ores which predominate in the second group are essentially diopside and hornblende-magnetite with some additional grains of feldspars, scapolite, quartz, and other minerals which entered into the composition of the original rocks before replacement by skarns and ores. Such mineralization is considerable and typically represented: among granitized schists on the flanks of the Tayezhnoye deposit, in the migmatite gneisses of the Sivagli and Tinskoye deposits, in cataclastic alaskites of the Legliyer deposit, and in other places (Fig. 3).

The magnetic ores replacing diopside-scapolite rocks surrounding the skarns also belong to the second group. These ores are represented most typically in the Pioneer (Pionerskoye) and, in part, the Sivagla (Sivaglinskoye) deposits. They are finely banded gneissic rocks with infrequent residues of migmatitic (quartz-feldspathic) material which has not been replaced by scapolite. The mass of the rock is irregularly brecciated and is cemented and replaced by magnetite. The replacement of feldspars and scapolite by magnetite is clearly shown in all ores of the second group without exception (Figs. 4 and 5). Hysterogenetic hornblende is developed as a rule at the expense of diopside and plagiocase.

Lime skarns (with slight magnetite mineralization) formed from schists and migmatite gneisses occur in most of the deposits of the region. They consist everywhere of andradite and an unusual dark-green clinopyroxene rich in ferric oxide, and, in addition, scapolite,

orthoclase, and quartz. The association of andradite and orthoclase is typical and indicates highly alkaline solutions [8].

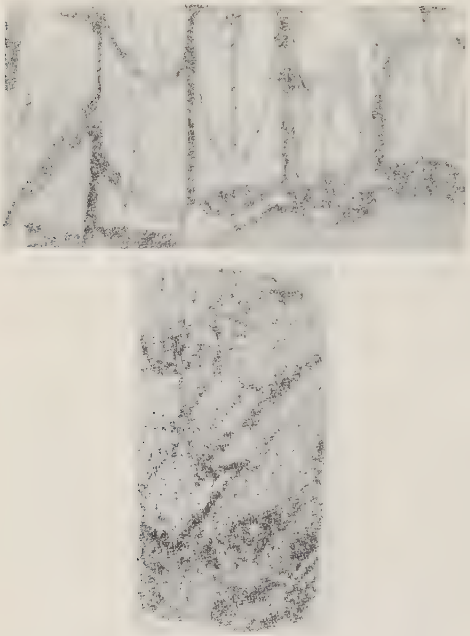

Fig. 3. Skarn-ore replacement of migmatized gneisses, Sivagli:

a - first stage of skarn formation (bore hole 57, $\frac{1}{2}$ natural size), b - highly altered migmatite gneiss; Mgt - magnetite, Ro - hornblende. Gn - gneiss (bore hole 92, $\frac{1}{2}$ natural size). These phenomena have also been described by D.P. Serdyuchenko as "granitization of sedimentary-metamorphic ores" in the Sivagli deposit.

The limestones in the Tayezhnoye and Magnetitovoye deposits contain complex boron-iron ores and the corresponding skarns are referred to postmagmatic apodolomitic formations. The leading primary borate, ludwigite, and the secondary asharite which develops hysterogenetically from it, enter into association with magnetite, olivine (clinohumite, serpentine), phlogopite, and, more rarely, with diopside. In addition, ludwigite develops simultaneously with magnetite during the main stage of formation.

In those sections of the Tayezhnoye and Magnetitovoye deposits which have actual borates in the skarn-ore layers, the fine-grained lenticular masses included in this layer and enveloping its seams of schists, are tourmalinized. Because the minerals most fully replaced by tourmaline in the first stage are the basic plagioclases and biolite, and to a lesser extent orthoclase and hornblende, and still less quartz and diopside, depending on the original composition of the schist and the intensity of the replacement process, a whole series of metasomatically altered tourmaline-containing rocks develop. For the majority of tourmaline concentrations, there are typical lenticular and fine-grained aggregations and inherited taxitic textures, which arise because some of the material of the original rock (most often migmatite stringers and pockets of isolated magnesian silicates) is preserved from replacement by tourmaline. The individual thickness of bodies which are essentially tourmaline rocks, do not exceed 1.5 m, but the extent is quite limited even when adjacent bodies combine. As a rule, such 'packets' containing a series of seams of tourmalinized rocks, as much as 20 m thick in individual cases, do not extend for more than 30 m along the strike or dip.[1]

Fine-grained tourmaline aggregates in alumino-silicate rocks, which have been replaced by skarn, frequently are inclusions already in the mass of skarn. The shapes of the ore bodies in skarns after carbonate rocks differ in deposits of this region. The main ore body of the Sivagli deposit is a typical "radish;" the ore bodies of Tayezhnoye are lenticular; in the Niricho deposits they are frequently pockets; and, in Levo-Des, they occur in sheets. The largest of the linear bodies is 1 km long. They are usually accompanied by suites of other, smaller bodies.

The skarn-ore bodies in migmatite gneisses and schists and also in the host rocks of the skarns are usually in pockets and lenticular; they often cut elements of the enclosing rocks (Tayezhnoye, Sivagla, Pionerskoye, and other deposits).

Carbonate deposits are granitized with relatively more difficulty than clays and other sediments. Consequently, residues of dolomitic marbles are nearly always preserved even in zones of postmagmatic skarn and ore formation. Ore bodies alternate along both strike and dip with marbles and calciphyres in the skarn zone (Fig. 1).

Within the individual ore fields, magnetite ore bodies are distributed along the strike with many interruptions; they form hanging walls, underlays or axes through the thickness of the former carbonate mass. The relationship between tectonic structures and mineralization stands out clearly in well-studied deposits.

Thus, the ore body of the Pionerskoye deposit occurs in a zone of considerable premineralization disturbance. The highly brecciated diopside-scapolite rocks surrounding the skarns have been replaced by magnetite. The northeastern part of the ore lens seems to be

[1] Serdyuchenko [14, p. 70-74] states that the thickness, and extent and distribution of these rocks have been thoroughly exaggerated.

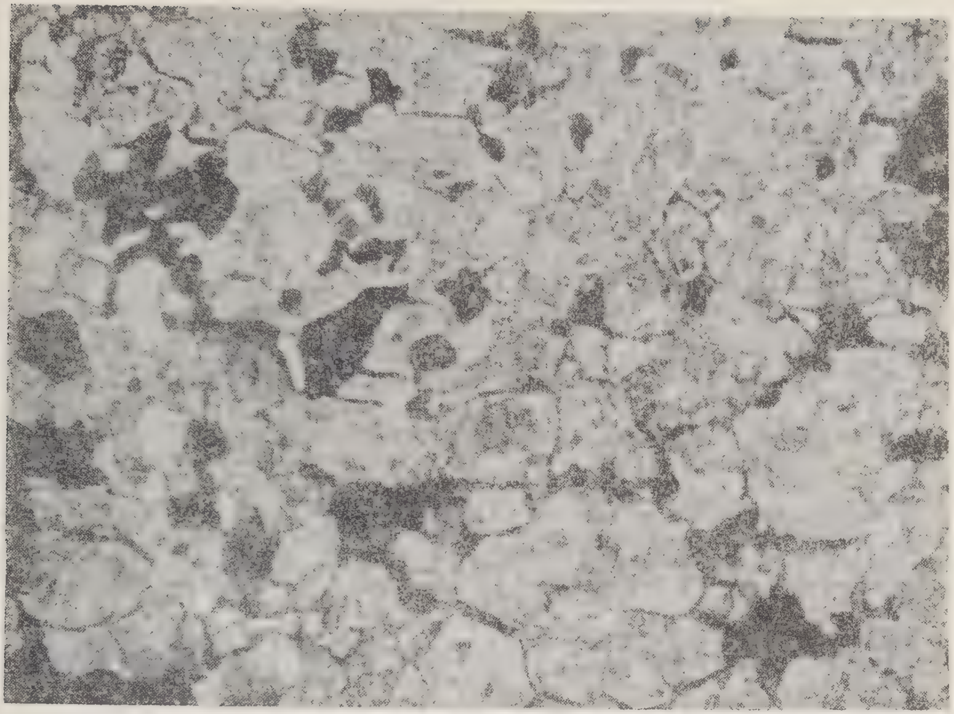

Fig. 4. Replacement of feldspars by magnetite in migmatite gneiss.

Pionerskoye, bore hole 6, sample 1031; "filaments" of magnetite penetrate into the feldspar grains, forming separate grains of magnetite. Nicols uncrossed, x20.

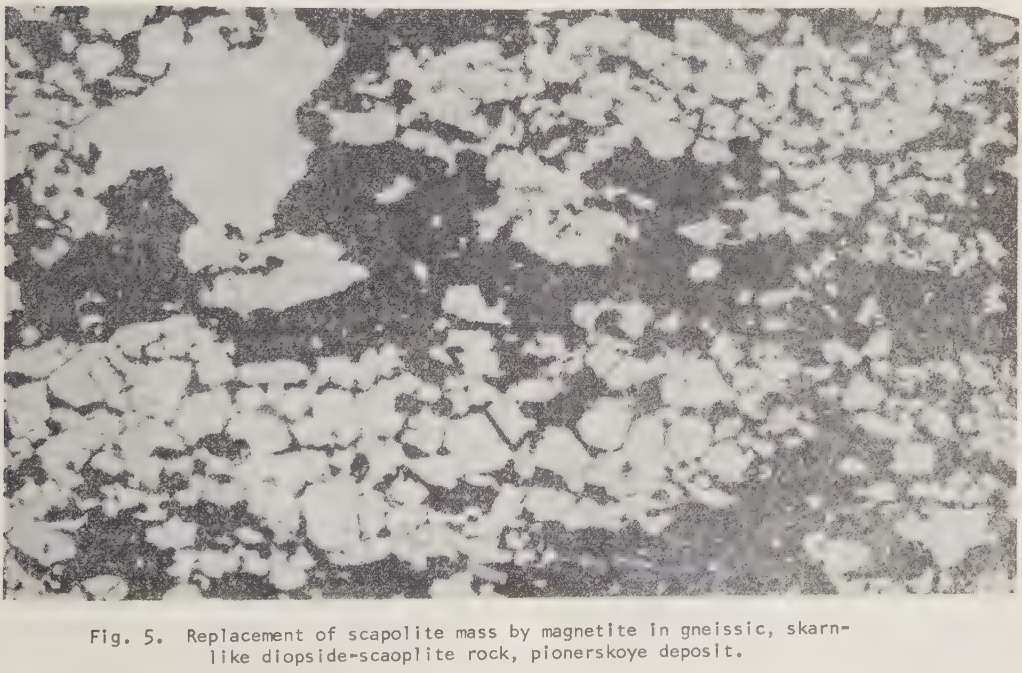

Fig. 5. Replacement of scapolite mass by magnetite in gneissic, skarn-like diopside-scaoplite rock, pionerskoye deposit.

Nicols uncrossed, x20.

replaced by unusual calcite marbles along the contact. The marbles are packed with fragments of diopside-scapolite rocks and schists which have been converted to skarns. There is no ore material in the fragments, although, in the south, these marbles (or more accurately calciphyre-breccias) occur with ores in longitudinal joints which cut across the strike of the host rocks.

Although calciphyre breccias occupy part of the ore body, and at the same time ore fragments or magnetite mineralization in blocks of host rocks are absent in these calciphyres, to consider the Pionerskoye ores as resulting from metamorphism of primary sediments [13, 15] must be recognized as futile.

In the Sivagla, Tayezhnoye, Legliyerskoye, and other deposits the most intense skarn conversion of gneisses, schists, and alaskites is confined to a zone of premineralization tectonic development (in the form of a crush zone). These zones do not always coincide with the stratification of the enclosing rocks.

The majority of deposits show clear linear structures due to premineralization differential movements, which directly influenced the morphology of the ore bodies, in the sense that these bodies originated after deformation of the carbonate mass. Premineralization disturbances contribute to more intense granitization of the crystalline series, in particular the dolomites, which are converted pyroxene skarns or other (especially feldspathic) rocks, whose chemical composition precludes ore deposition. Thus, tectonics have some effect on mineralization.

Because iron-ore deposits of identical type are known in at least three different horizons of the complex stratigraphic sequence of the Aldan shield and are separated by great thicknesses of schists and gneisses, it is impossible to speak of a single ore-bearing horizon. Some concentration of iron of another type is known in the Lyengrskian quartzites which are lower in the sequence than the Fyoderovskian. The obviously metasomatic magnetite concentrations of the Fyoderovskian series are unique in the region. The dolomite marbles which alternate with the skarn-ore zones along the strike contain no ore minerals or boron detectable by chemical means. The dolomite marbles do not contain silicates and have not been converted into calciphyres, as is typical of the dolomites in the skarn-ore zones. No minerals are present, which would indicate formation in salt-lagoon conditions. The areal extent of these masses of limestone and the comparatively great thicknesses indicate deposition in a basin and precludes the possibility of haloidal or other conditions of high salinity. The conditions are those of the open sea, and not of a coastal lagoon.

These and other features of the deposits lead us (in agreement with Korzhinsky) to the conclusion that they are metasomatic.

Dolomites and the various alumino-silicate rocks with which they are in contact are not in chemical equilibrium, and an interaction occurs in the presence of solutions ascending from a granitic magma. As a result, both rock types suffer some degree of metasomatism and develop reaction zones with definite composition.

The iron present in the rising solution occupies a position in the reactions, enters into the composition of the silicates and separates as magnetite in a basic medium in the carbonate rock or skarn which is undergoing replacement. If the alkalinity of the solutions is increased, the iron replaces the minerals of alumino-silicate rocks as well. When the concentration of boron in the solutions is increased, the boron interacts with the minerals of the rock being replaced, and forms borates in a basic magnesian medium, and tourmaline in an alumino-silicate one.

The main mass of the ore was formed postmagmatically when migmatite gneisses and even alaskite granites were subjected to the same skarn-ore replacement as the dolomites. The presence of primary concentrations of sedimentary iron and boron in the locality of known ore bodies is unknown. The role of iron entering into the composition of those primary deposits can be considered negligible.

According to Sudovikov and Krylova [19, pp. 118-119], ore deposition in these deposits resulted from iron-magnesium metasomatism. This took place during a progressive (magmatic) stage of metamorphism and was of a local character. The upper structural series must have existed during this phase, for it was penetrated by solutions rich in iron, magnesium, and calcium, from a granitization zone occupying a deeper position.

Skarns, ores, and circumskarn formations of the postmagmatic stage decidedly predominate in the deposits of the region. Besides this, the deposits coincide exclusively with the contact of the dolomites with the alumino-silicates and are absent from the contacts of the latter with the calcareous marbles. Granitization is generally absent in the central Aldan deposits. These facts are inconsistent with the idea that the formation of these deposits occurred during the magmatic stage of metamorphism, and also that ore formation is related to regional metasomatic (in the sense used by Sudovikov) processes.

Serdyuchenko has developed an idea that the iron ores of the region were formed by regional metamorphism "of ancient iron sediments with subsequent action of infiltrating metasomatic

processes." The iron ores of these sediments are of chemical origin. The igneous rocks "were injected into ore zones already in existence... under the action of granitic magma, a transfer and local precipitation of the ore material took place" [14, pp. 54-57].

It is stated that garnet (andradite), amphibole, pyroxene, and scapolite rocks were formed as the result of contact-regional-metamorphism "of marly and lagoon-lacustrine saline deposits under the action of... ancient granite masses" [13, p. 115]. "In the coastal-lagoon zone of the ancient sea... besides the large-scale concentration of iron, an enrichment... of the rocks by boron took place" [14, p. 90].

Considered as basic arguments for this point of view are: a) conformity of the ores to a given stratigraphical horizon; b) conformable stratification of the ore bodies and ore-bearing zones with other clearly sedimentary-metamorphic rocks and portions of them together with these rocks, in the development of ancient geologic structures; and c) alternation of ore bodies with paraschists, paragneisses, and marbles: "the presence... of transitions from uninterrupted and rich ore to banded and disseminated ores and to ore-free rock analogous in composition to the seams or disseminations in the ore zone of the same stratigraphical horizon or mass."

Besides this, "the structural-tectonic and mineralogical similarity of the Aldan ores to many Precambrian iron ores, known to be sedimentary-metamorphic deposits," was pointed out and also "the more ancient age of the ore bodies and ore-bearing zones, in comparison with the oldest period of migmatization in the Aldan... and with the granites" [14, p. 63]. Additional arguments are: the lack of ores in the alaskite granites in the Slyudyansk Precambrian complex and the paucity of titanium in the Aldan magnetites.

Because carbonate rocks which are undergoing skarn-ore replacement occur as strata, the absence of conformity to a definite stratigraphic horizon would be remarkable in the type of contact-metasomatic deposits under discussion. The facts already given as to the distribution of the iron-ore deposits of the region in the general geologic section of the Aldan shield show how unfounded are the assertions that there is the one ore-bearing horizon in the region.

A considerable number of large ore bodies in the southern Yakutian deposits are unconformable in relation to the elements of the strata enclosing their hosts (dolomites and schists and alaskites). Generally, the conformable (or nearly conformable) strata of ore bodies in typical contact-metasomatic deposits are seen often enough and cannot serve as an argument for complete sedimentary-metamorphic character of the mineralization.

When masses of skarn-ore rocks are of great thickness and extent in ancient structures, they should share the fate of the rocks enclosing them. The formation of the Aldan structures was indisputably completed for the most part before granitization. Under these conditions, coarse ore bodies and the skarns directly enclosing them should as a rule be migmatized and carry injections of granitic material to an extent commensurable with the intensity of these phenomena in the enclosing gneisses and schists. It is known that these manifestations, as well as any signs of metamorphism of ores, are absent from the deposits of the region.

Assertions as to "the share contributed by the ore bodies to building the ancient structures" thus appear to be the result of disregarding the fact that the forms of the ore bodies and the skarns enclosing them are inherited from the structures of the replaced rocks. Dolomites which were replaced were part of the old structures, but not all the skarns and ores have been formed in their place.

It is generally known that the introduction and removal of components from a rock is very limited in regional metamorphism. It is comparatively significant only for volatile components, such as water, carbonic acid, and, at times, chlorine and fluorine. Numerous observations have also firmly established the idea that deposits of similar chemical composition, which are subjected to regional metamorphism under the same conditions, form rocks of the same mineral composition.

Consequently, both these aspects are obviously to be regarded as reasonable when applied to the actual conditions of the metamorphic complex of the Aldan shield. In this case, the question arises: on the strength of what causes, in the Tayechnoye deposit, for example, do the regionally metamorphosed (according to Serdyuchenko) rocks enclosed in two almost adjacent layers and of the same chemical composition, turn out to be built up of ludwigite in the one case and of tourmaline in the other?[1] And why are not ludwigite and tourmaline formed together under similar conditions? Obviously, the separation and contrast of such regional-metamorphic "facies" as ludwigite and tourmaline do not by themselves have an adequate petrological foundation.

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[1] For example, the chemical composition (in grams per cm^3) of the rocks; 10 percent tourmaline + 60 percent diopside + 20 percent phlogopite + 10 percent pyrite (sample 3475) and 5 percent ludwigite + 50 percent diopside + 33 percent phlogopite + 5 percent olivine + 5 percent calcite + 2 percent magnetite (sample 1561) are: SiO_2 = 1.37, 1.31; Al_2O_3 = 0.16, 0.14; Fe_2O_3 + Fe = 0.35, 0.38; MgO = 0.52, 0.61; CaO = 0.50, 0.53; alkalines = 0.06, 0.09; B_2O_3 = 0.03, 0.03.

The deposits of the Aldan shield are situated at the contacts of alumino-silicate rocks with dolomites which are not in chemical equilibrium with them. There is no mineralization at the contacts with limestones and with magmatic magnesian skarns.

If, in agreement with Serdyuchenko, the magnesian skarns and ores of these deposits are to be regarded as having been formed as the result of regional metamorphism of deposits of corresponding composition, the subsequent (postmagmatic) reaction of the greater part of these skarns and magnetite ores with the alumino-silicate rocks at their contact will be impossible (being in chemical equilibrium). Meanwhile, in the deposits in question, the reaction of the rocks at the contact is expressed by the presence of a certain composition and constitution of the zones and is a characteristic feature of the deposits. This is evidence that the magnesian skarns and associated ores are not sedimentary metamorphic formations, but are the result of replacement of comparatively pure dolomites in a reaction zone.

The stability of plutonic calcite in the Aldan facies, in association with quartz and orthoclase, explains the absence in the Aldan shield of metasomatic phenomena and magnetite mineralization at the contacts of alumino-silicate rocks (including alaskites) with limestones. Such phenomena are typical only of dolomites here. From Serdyuchenko's point of view (the contemporaneity of primary concentrations of magnetite and carbonate and other rocks of the section), the absence of mineralization of limestones in this region is inexplicable.

All geologists who have studied the crystalline complex of the Aldan shield are unanimous in noting that one of the most characteristic features of its rocks is the almost complete absence of the middle- and low-temperature modifications of minerals. Where these modifications are common, they always are due to much later magmatism or to ore-formation processes [6, 20]. If ore formation is due, as Serdyuchenko claims, to regional metamorphism, the appearance of the hysterogenetic modifications of high-temperature minerals which are constantly observed, irregularly but quite intensively in the ores, skarns, and the rocks enclosing them cannot be explained. These occurrences are marked only at the boundaries of deposits, and are undoubtedly due to magmatic activity in the Archean. Adherents of the sedimentary-metamorphic hypothesis of the formation of iron-ore deposits of southern Yakutia must explain why some of the rocks of the Archean shield complex, namely those in the ore fields, did undergo the same changes as the crystalline series.

Because the dolomites, including interlayered alumino-silicate rocks, were replaced, the first part of the third argument is unconvincing because of the arguments stated in the discussion of the first two. The relevancy of the transition from rich ores to oreless rock can be noted in what follows. In the first place, transitions between ores, skarns, and dolomites are, as a rule, rare in these deposits. Cases of "gradual" transition are actually the common irregularities of mineralization, due to a general nonuniformity of intensity of metasomatic replacement and the selectivity of ore replacement. Furthermore, the presence in the ore of minerals which are constituents of the skarns outside the ore body along the strike, cannot for obvious reasons be regarded as an argument against metasomatic ore replacement of these skarns (in this case, incomplete).

In all his papers, Serdyuchenko conceals the existence of a distinct zoning which cannot but be seen in the structure of these deposits. It can be pointed out here that the transition from an ore body into both dolomites and alumino-silicate rocks is always accomplished along zones in the skarns and their host rocks, which maintain their chemical composition and position.

Serdyuchenko's assertion that the ores are "interstratified with and intimately related to borate concentrations and tourmaline-bearing rocks," and also "of great thickness and extent," contradicts his arguments as to the formation of this rock complex under coastal-lagoon, but still saline, conditions.

The reasons why iron deposits in Precambrian time are mainly represented by ferruginous quartzites is well known. Salt-lagoon conditions are primarily those of an arid climate during which the weathering is alkaline in character and the iron does not migrate, but remains in place ("desert varnish" and other phenomena). While lime and magnesian salts are separated from the solutions in the saline lagoons and lakes, the conditions for migration and sedimentation of chemogenetic iron are not realized. It is true that boron can migrate and be deposited in these conditions. But what then is to be done with the existing complexes of ludwigite-magnetite ores and with the permissible (but not actually in existence) thick sedimentary concentrations of iron?

Serdyuchenko's first three arguments, which he himself regarded as the "decisive factors" [14, p. 63], are revealed as inadequate in the light of the data which have just been briefly analyzed. The statement that mineralization is much earlier than the granites contradicts the facts pointed out above.

The postmagmatic character of the greater part of the skarns and ores of the region is emphasized by the wide development of the skarn-ore replacement of migmatites and even

granites. The rare injections of granitic material into some of the skarns and ores of the two deposits are accompanied by some other features in the mineralogical composition of these skarns and in their reactions with the material of the injections (see above). These features accord completely with those which should take place when such a part of the skarns and ores is formed from existing lime-carbonate rocks during progressive metamorphism.

The arguments for the sedimentary-metamorphic character of the Aldan ores with reference to the ore-free alaskite granites of the Slyudyanka region is rather comic. In the states of New York and New Jersey, U. S. A., mineralization is associated with alaskite granites. Geologists working on ore deposits know of a great number of cases where the one mass of homogeneous (by composition); carbonate rocks has skarn mineralization in one place in its contact zone, but none in another.

In support of the sedimentary-metamorphic origin of the Aldan deposits, Serdyuchenko points out, that "in support of this point of view it is enough to speak of the structural-textural and mineralogical similarities of the Aldan and many of the Precambrian iron ores... the Krivoi Rog and Kurskaya magnetic anomalies, the northwestern part of the Kola peninsula" [14, p. 63]. But it is generally known that the ores of these deposits, true products of sedimentary metamorphism, are predominantly represented by absolutely different quartzites, and there is decidedly no structural-textural or even mineralogical similarity to the main mass of the serpentine and to the phlogopite-magnetite and other skarn ores of Aldan. No one can advance such parallels without being struck by the lack of examples on which to base them.

Serdyuchenko's last argument, the poverty of titanium in the Aldan ores, is unfounded. Low titanium is known to be typical of many metasomatic iron ores.

In the article about the tourmaline-bearing horizon in the quartzites of the Aldan range, Mitich [12, p. 247] writes of some rocks of the Lyengrskian series as the oldest upper Archean formation and, in particular, of these quartzites as being the base of this series. Serdyuchenko, correlating these quartzites with those of the Tayezhnoye deposit, writes [16, p. 823] of the quartzite series as the upper part of Lyengrskian series.

Geiger, on the ludwigite-magnetite ores of central Sweden, writes [26] "a review of the literature on ludwigite shows that the many deposits in different parts of the world are all known as typical products of contact metasomatism," and, further "systematic observations of paragenetic relationships... indicate such complete analogy with the ludwigite-bearing assemblages of other places, as to make it obvious that the Swedish deposits should be interpreted in exactly the same way as the others, that is, as the result of contact metasomatism." Disregarding these conclusions of Geiger, Serdyuchenko writes [16, p. 824]: "in central Sweden... magnetite-ludwigite iron ores are known (further reference to the paper by Geiger which we have cited) like other ores of this region to be of sedimentary-metamorphic origin."

Watanabe, in the chapter on metamorphism and metasomatism in his monograph on the Hol-Kol deposits, discusses the borate mineralization (with kotoite the dominant mineral) and, on the basis of the clearly expressed skarn type of mineralization, the distinct metasomatic zoning, the deep-pipe form of the ore bodies, and other features of the deposit, regards it as metasomatic [31]. Referring to this paper, Serdyuchenko says nothing of Watanabe's conclusions and 12 lines after the reference, writes [16, p. 825], "with ludwigite or replacing it in borate sedimentary-metamorphic facies, occur fluoborite, kotoite, and other boron minerals." Reality is also distorted in that ludwigite, which is quite subordinate among the Hol-Kol minerals, is assigned a dominant role by Serdyuchenko ("widespread occurrence of ludwigite accompanied locally... by kotoite"). Similarly, rare traces of tourmaline in the mica schists of the region at their contacts with pegmatites become "tourmaline" phyllites and mica schists.

Hotz [27] and Sims [29] regard the iron ores of New York and New Jersey as typically metasomatic because of the presence in the deposits of a relationship between the mineralization and the structural elements, the transgressive nature of some of the ore bodies, the clear epigenetic situation of the magnetite, and other factors. Disregarding this, Serdyuchenko uses these deposits to demonstrate (by analogy) the sedimentary-metamorphic genesis of the Aldan (!) deposits.

Serdyuchenko treats a wide circle of not readily accessible geologists in the same way as he does foreign authors. He enters into an original form of dispute with the authors of the works he cites concerning regions and deposits with which he is acquainted only through the literature. The arguments of these authors (and even their factual data) are taken as inconclusive, and on this basis their opinions are straightaway changed into contradictory, speculative inferences.

Sobolev's work on Yearsakpaya [18] has been treated in this way. He had come to a fully substantiated conclusion that the tourmaline in the diafluorite muscovite schists was due to magmatic processes. In a similar way, works by Afanasyev [2], Lebedev [10], and Volarovich [3] on Malyi Khingan were used to

demonstrate the correctness of Serdyuchenko's way of thinking. In these papers the authors give a faultless demonstration of the magmatic character of the tourmaline in the schists of the region. But such conclusions will not do for Serdyuchenko; he regards them as unconvincing. Consequently, in one of his articles [16, p. 824], he does not, in general, consider it necessary to acquaint his readers with the opinions of the authors on the disputed questions, but alters them to his own contrary ideas. In another of Serdyuchenko's papers [17, p. 93], the remark by Afanas'yev that tourmaline in schists rarely differs from tourmaline in pegmatites, the word "rarely" was changed to "suddenly" (it is true, with a reservation as to fact of replacement). Although the difference in color in tourmalines depends directly, of course, on the chemical differences of the medium in which the mineral is formed, and in themselves they cannot serve as an indicator of any one mode of origin, to change "rarely" to "suddenly" without any reason is hardly admissible even in this case.

Serdyuchenko's final conclusion [17, p. 96] refers to the tourmaline granites of Malyy Khingan tourmaline is a "contamination" mineral in granites! and shows that he has no wish at all to consider either the factual data for the region (on which he has not worked) or the elements of present-day ideas on the conditions of crystallization of granitic magmas. He obviously does not note that his conclusion of accumulation (and transfer) by the granites of chemicogenetic boron from the "old deposits" in the Archean crystalline complex of the Aldan refers to conditions which are the reverse of those in the Malyy Khingan. Typical features of the Aldan are known to be the special granitization of the schists on the one hand, and, on the other, the almost complete absence of tourmaline in the granites and in the granitic parts of the migmatites (even in deposits of boron-iron ores).

Serdyuchenko's enthusiasm in his search through the pages of the literature for new sedimentary-metamorphic boron deposits is not unsuccessful, even although he regards other mineral deposits as skarns.

Thus, having reiterated in 18 lines the geology and petrography of eastern Zabaykal'ya [17, pp. 99-100] and emphasized the presence of calcite, diopside, epidote, garnet, and axinite in the phyllites, he comes to the conclusion that the relationship between the boron mineralization in the Priargun'ye and the skarn deposits of lead-zinc ores "is not to be considered as an argument in favor of boron being primary-metasomatic," but, conversely, in the light of the sedimentary-metamorphic origin of boron and iron[1], the genesis must be reconsidered as "due to the boron of the lead-zinc ores" of the region.

Serdyuchenko's logic is original. He is not to worry about proving his conclusions, because he considers that there is no proof that they are incorrect. The distortions of fact in Serdyuchenko's papers are so numerous that it is perfectly impossible to cover even the most important of them in a small article. These distortions are due not only to his complete rejection of self-control in following up the ideas which have captivated him, and a carelessness in manipulating his facts, but to his incorrect evaluation of the significance of any fact used to prove a thesis.

Serdyuchenko finds in a scrupulous description of the geometric relationships of rock minerals in thin section (more rarely in the mass) a basic method of demonstrating the sedimentary-metamorphic origin of some rock (or individual mineral). Examination of the geologic conditions are mainly reduced to indications of the form of the rock deposit and to its position in the section.

A paragenetic analysis of the causes of mineral associations and an explanation of the laws controlling the position of the individual rocks in the section find no place in Serdyuchenko's works. Meanwhile, it is well known how completely the composition and structure of a rock which is being replaced can be altered by intense metasomatism. Individual changes in a complex conform strictly to rule.

It is obvious that in these conditions, analysis cannot be replaced by a study of particular minor (because isolated) details of rock structures. Even the specific terminology, widely used by the author, is of no use here, whether it is "mineral phases" (instead of "minerals") and "chemical appearance of the rocks" [16, p. 53], "reaction capacity of a component" [16, p. 56], "phenomena of convergence" [16, p. 59], and so forth.

Serdyuchenko recognizes the intensity and complexity of the metasomatic processes but makes no endeavor even to try and unravel them. He is constrained by the very superficiality of his qualifications: "complicated," "multiform," and so forth. Along with this, he recognizes as possible "removal" of changes of composition and rock structure due to metasomatic processes.[2] Readers will verify, for instance, that "in all cases of 'removal'... of secondary superimposed effects which we have clearly traced, and also the geologic conditions of deposition and microtexture... of the

[1] Also a contention by Yefimov [4].

[2] Also to metamorphism and migmatization [17, p. 59].

rocks, lead to the definite conclusion that tourmaline is syngenetic with other parametamorphic minerals and that it is formed at the expense of older boron-containing... (chemogenetic) sediments." Those who are acquainted with Serdyuchenko's papers on these questions will be easily satisfied that there is no characteristic example of the effect of metasomatism on the rock and ore complexes under discussion in any one of them.

It is hardly necessary to point out that beyond correlating the extent and type of the metasomatism with the conditions of formation of the deposits, unless a study of the regular mineral assemblages which are the results of these processes is made, any type of "removal of superimposed processes" appear to be an arbitrary subjective effect.

Excluding everything which is unnecessary for the preselected result, Serdyuchenko does not, for instance, touch tourmaline (and some other minerals), including it just the same in the sedimentary-metamorphic minerals. Even such absolutely clear superimposed processes as the replacement of olivine by clinohumite and serpentine are "removed." As a result, it transpires that the main mass of magnetite is developed from serpentine [13, p. 120; 14, p. 59] and not from olivine. Obviously epigenetic magnetite in alumino-silicate rocks becomes "sedimentary metamorphic." Besides this, it has, regrettably, to be said that a whole range of factors contradicting the author's conclusions are simply omitted: the widespread occurrence in the Tayechnoye deposits of tourmaline replacement cutting across the foliation of schists (Fig. 6), the development of essentially scapolite rocks only in association with the processes around skarns always in the same geologic position (in one zone of the metasomatic column), and a whole range of other factors already mentioned.

Only a complete disregard of the laws governing mineral assemblages can explain the frequent gross inaccuracies shown by Serdyuchenko in the details of rock composition in his papers. The fact that, for example, phlogopite is not formed in paragenesis with feldspar in the quartz-bearing rocks in the conditions prevailing in the Archean complex of the Aldan shield is generally known, as is the reason (biotite is formed instead). Nevertheless, Serdyuchenko writes of "plagioclase-phlogopite-quartz gneisses" [15, p. 744].

Such disregard also explains the emphasis on the absence in the lime (andradite) skarns of such a mineral as ludwigite [17, p. 105], which is characteristic of magnesian skarns, and also gives rise to perplexity at the mention of dumortierite in the magnetite ores of the Tayezhnoye deposit [14, p. 70]. Serdyuchenko makes use of rock structures and textures in building up a considerable part of his conclusions. Besides this, he overestimates the significance of external features, and, as a rule, avoids discussion of all the possible causes of any of these features. In particular, he completely excludes the part played by inherited textural features, such as quartz-feldspathic material in migmatite schists usually segregated as clots, lenses, stringers, and other forms. Both clinopyroxene and hornblende being developed from it form such segregations. When a crystalline schist is partially replaced by tourmaline (or andradite, scapolite, or some other mineral) plagioclase and biotite are replaced in the first stages, but the material of the segregations usually persists. Besides this, the clots and veins composed of this material, naturally appear to be enclosed in a tourmaline (andradite) mass; this gives an impression that this enclosing mass is the later formed. But when these clots and veins are traced down to where they continue from the tourmalinized mass into the unaltered part of the schist, it is always possible to be convinced of their derivation: neither these or any other possibly more thorough analysis of the causes of these or any other textural features of metasomatically altered rocks are used at all by Serdyuchenko.

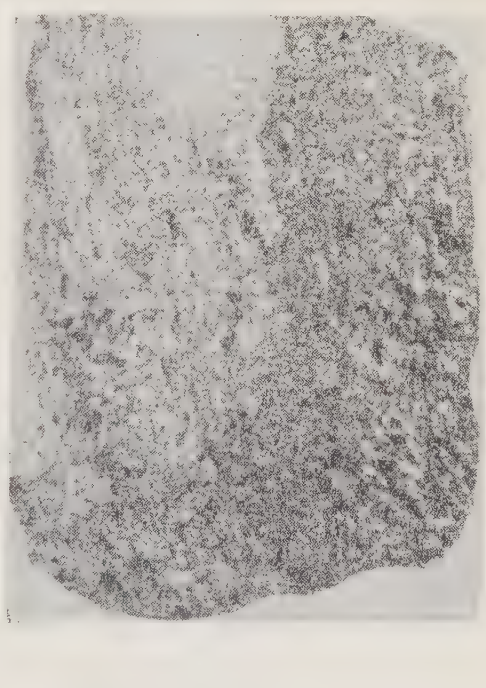

Fig. 6. Tourmaline replacement cuts down the banded ("layered") texture of crystalline hornblende schist. The fine-grained tourmaline mass is formed in both the hornblende zone, and the ferrous phlogopite zone.

Tayezhnoye, bore hole 33, sample 1092; ½ natural size.

All this, together with other facts already cited, convinces that the evaluation of metasomatic processes ("intensive," "complex," "manifold") and their role in the formation of the deposits in question are of an entirely formal character in Serdyuchenko's papers.

The significance of these processes is regarded as lying only in words which are used to give a semblance of objectivity to their author's conclusions, and not in facts to be used in their construction.

Even Serdyuchenko recognizes this, although in a somewhat veiled form. Thus, he invites readers to agree with him, that "it is much simpler and more natural" to regard the concentration of boron (as kotoite and other borates) in the Hol-Kol gold-copper-bismuth deposits in Korea as "primary-sedimentary" in a dolomitic series [17, p. 102] later regionally metamorphosed. The effect of an intrusion is discerned here only in "the hydrothermal transfer of boron compounds." This appeal completely ignores the clear evidence of the contact-metasomatic character of the deposits which Watanabe [31, 32] has described and discussed with proper completeness and conviction.

Serdyuchenko's method of argument (it is well known that the simplicity of an argument has never been, as far as science is concerned, a criterion of the truth of the argument or a testimony to the progressivity of outlook) is not the only noteworthy aspect of the example just given: there is also the absurdity, in the light of known facts, of his contention that a primary chemical accumulation of boron is possible and that it has taken place in thick dolomitic masses to an extent of 10 to 12 percent (based on the 30 to 35 percent content of kotoite in the mineralized dolomite marbles of Hol-Kol). It is true, he asserts that in the Archean "in the zone of sedimentary accumulation there separated many more compounds of boron" than took place elsewhere under the conditions prevailing at the same time [17, p. 109]. But for unknown reasons, he does not let readers know that, for instance, in Cambrian dolomites at their contact zones with granitic rocks in eastern Zabaykal'ye, or at similar contacts with dolomites of Jurassic age in Rumania [28], there are considerable concentrations of borates in the skarns of lead-copper-rare metal (Betstsa-Bikhor) and iron-ore (Banat) deposits.

From these and other statements which Serdyuchenko lets slip out emerges the shape of the problem which he has posed for himself. This clearly comes down to a desire to demonstrate by any means that there is only a chemical source for the boron in the minerals of skarn deposits. A study of the actual features of composition and structure of the deposits, of the complex chain of cause and effect during their formation and the scientific basis of prospecting criteria is not for him.

It must obviously be concluded from what has been said that the southern Yakutian deposits exclude an objective judgment of the question which is agitating Serdyuchenko. There are other less complex deposits both in the U. S. S. R. and outside it, where the geological situation of a ludwigite-magnetite mineralization does not admit a different interpretation of its genesis. The mineralization is located in a narrow (some meters) zone of direct contact of boron-free dolomites with granitic rocks. There is an abrupt development of metasomatic zoning (analogous to that observed in the Aldan deposits) at the contact. The Kunduyskoye deposit in the Buryat-Mongolia, A. S. S. R., and the contact of granites with Cambrian dolomites in Skye, Scotland [30], and so on can be cited as examples.

The peculiarities of Serdyuchenko's logic in those of his papers which have been discussed in part here have already been mentioned. Only the following must still be noted. The system of demonstration which he uses, rests mainly on the selection of facts torn from their context and considered to have a significance impossible from other viewpoints. Even when greater significance is to be given an outstanding (according to his outlook) individual aspect, he uses an energetic turn of speech rather than the relationships of logic. His papers under discussion abound in replacements of fact by such words as: "identical," "evidently," "indubitably," "typically," and, after using all that are known of these, "therefore."

It seems expedient to call to mind some general propositions from the study of logic. "The actuality surrounding us... is so complex and diverse, that more or less any number of individual factors can be selected to verify any proposition, even one that is obviously absurd. However, the circumstances that there are factors which disprove a certain proposition, indicates that single factors, taken by themselves and torn from their context, prove nothing" [1, p. 21]. And further: "the bases of proof should not even be doubtful. Only complete conviction of the veracity of all the foundations (that is, facts, concepts - L. S.) on which the proof rests, makes it the ways and means of discovering (when all the other conditions and stipulations are kept) a new truth" [1, p. 36].

And finally (in connection with the energetic verbiage already referred to) it must be borne in mind that if the proposition concerned is false (not agreeing with actual facts) means of refuting it will be found sooner or later. What has been said is well illustrated in this case by the most recently discovered facts, such as the ore free nature of the calciphyres of the Pionerskoye breccias already mentioned.

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FEATURES OF THE MINERALOGY AND GENESIS OF THE TIN-BERYLLIUM-FLUORITE DEPOSITS OF THE FAR EAST

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ABSTRACT

The features of a tin-beryllium-fluorite mineralization are discussed. The deposits are significantly different from the deposits of tin, beryllium, and fluorite described in the literature. Mica-fluorite ores and topaz greisens occur at the contacts of granites with ore bodies, and, therefore, the mica-fluorite rocks are unusual desilicated greisens formed from the replacement of limestones by fluorine solutions poor in silica.

GENERAL FEATURES OF THE ORE BEARING AREA

The area in the Far East known to contain deposits of tin, beryllium, and fluorite is underlain by Cambrian limestones and slates crumpled into parallel folds with a northwest strike. The folded structures are broken by numerous faults and intruded by leucocratic granites and hybrid rocks of intermediate and basic composition. In the field, these intrusions are clearly related to one another and the ore deposits, and are mostly in the form of oblong stocks and veinlike bodies elongated along the strike of the folds. Massive biotite granites are sometimes also seen within the ore-bearing area, and, according to Rub, they form a single intrusive complex with the leucocratic granites and the hybrid rocks. Rub [8] suggests that the formation of this complex begins with the intrusion of hybrid rocks due to the accumulation of depth of limestones and other rocks in a granitic magma; the coarse masses of biotite granite were then formed, and, still later, the small bodies of leucocratic granites and the ore deposits.

The mineralized areas containing tin-beryllium-fluorite deposits are usually elongated along the axes of the folds. Some parallel ore zones are usually seen within the ore-bearing area. Associated with the tin-beryllium-fluorite formations are also cassiterite-quartz and cassiterite-sulfide deposits.

The tin-beryllium-fluorite deposits are clearly subdivided into two types: mica-fluorite and tourmaline-fluorite.

THE MICA-FLUORITE TYPE OF ORE DEVELOPMENT

The main mica-fluorite ores are most frequently situated in the exocontact aureoles of the leucocratic granite intrusions. The ore bodies conform to localities which are cut by a dense network of northwest, northeast, and east-northeast fractures. All these fractures are cut by numerous porphyry dikes.

The ore bodies have the form of an almost vertical pipe which narrows downwards and which has been formed in a crush zone at the expense of the enclosing limestones and skarns. In plan, the ore bodies are north elongated lenses. In other places, the ore bodies are elongated with irregularly curved outline.

Muscovite-quartz and plagioclase veins are the earliest postmagmatic formations of the mica-fluorite deposits. Both are usually not very thick and are encountered among granites, fluorite ores, and limestones. Molybdenite and high-temperature molybdenite are found locally in the plagioclase veins, which consist of albite and oligoclase. Muscovite-quartz and plagioclase veins are often found together; the intersection of muscovite-quartz veins by plagioclase veinlets is clearly observed in some cases. The formation of the plagioclase veins is evidently associated with the albitization of the granites, which was most intense in the apical portions of the granite-porphyry intrusions.

The various fairly widely distributed skarn rocks were formed after the muscovite-quartz and plagioclase veins. The various types of skarns are distinguished by their mineralogical composition: garnet, pyroxene, wollastonite, scapolite, and vesuvianite-garnet. Segregation of magnetite is seen in the pyroxene and garnet varieties. Later actinolites are associated with typical skarns. The skarn bodies are in the form of small clots and lenses and of thin seams developing near the contacts of granitic bodies and replacing limestones, porphyrites, and plagioclase veins.

Greisens are widely distributed among fluorite deposits. The pre-ore type, caused by the autopneumatolysis of the granitic intrusions and the greisens surrounding the ores, which are the result of the action of ore-forming solutions on the granites and earlier greisens, are clearly distinguished. Greisens of the first type are the mica-quartz variety, and the greisens surrounding the ores are quartz-topaz and quartz-mica-fluorite types.

The topaz veins occurring in slates in some localities are obviously clearly related genetically to the topaz greisens. Like the topaz greisens, they are characterized by the presence of cassiterite, wolframite, and columbite.

The age relationships of the autopneumatolytic and circumore greisens are best seen in the granitic dikes which occur within the cylindrical ore bodies. Here, typical muscovite-quartz greisens occur as rare relicts in a quartz-topaz greisen, with topaz replacing not only primary quartz but even the earlier mica of the greisen.

The formation of topaz greisen evidently took place at the same time as the initial stages of formation of fluorite ores. The presence of isolated fragments of fluorite ores in the topaz greisens at their contact with the ores allows the fluorite ores and topaz greisens to be considered as having been formed from the same ore-bearing solutions but by the replacement of rocks of different composition. Under these conditions, xenoliths of the surrounding limestones in granites were converted into a fluorite rock while the granite was being transformed into a topaz greisen.

The mica-fluorite varieties of the greisens occur at the contacts of granites with fluorite ores, that is, in those places where the contact reactions result in an increased concentration of calcium. The other part of these greisens is obviously due to the later stages of formation of fluorite ores.

The fluorite ores can be subdivided into three types: mica-fluorite, topaz-fluorite, and diaspore-fluorite, of which mica-fluorite ores are the most widespread. The fluorite ores enclose a great number of veins which differ in composition; some of these are veinlets which were formed at the same time as the replacement ores by filling the numerous ore-feeding fissures and a few generations of epigenetic veins. Those with muscovite are the most important, and also the various veinlets with beryllium minerals, and the sulfide veins and seams composed essentially of sphalerite and pyrrhotite-sphalerite.

The mica-fluorite ores generally consist of a fine-grained grayish-violet or dark-violet rock, composed of fluorite and a bright mica (muscovite), or alkaline brittle micas of the ephesite type. The abundant minerals in the ores include tourmaline, phenacite, chrysoberyl, calcite, scapolite, cassiterite, sellaite, and graphite; those seldom occurring are topaz, quartz, euclase, beryl, corundum, diaspore, apatite, and cryolite.

The mica-fluorite ores are divided into four types, based on mineral composition and features of texture and structure: 1) coarsely crystalline muscovite-fluorite ores with phenacite augen, 2) finely crystalline muscovite-fluorite ores with massive phenacite, 3) finely crystalline ephesite-fluorite ores with massive chrysoberyl, and 4) finely crystalline ephesite-fluorite ores with scalloped fine bands of chrysoberyl.

The most widespread is the fine-grained muscovite-fluorite, then the massive ephesite-fluorite ores. The muscovite-fluorite ores with augen structure and the fine-banded ephesite-fluorite ores are of restricted development and occur, as a rule, in the upper parts of the deposits. The augen ores form lenses and clots among the finely crystalline massive ores and are transitional with the most coarse-grained varieties of the latter. The fine-banded ores comprise feeble veins and seams which often accompany the augen ores.

The fluorite content in the mica-fluorite ores varies from 55 to 75 percent, that of the mica minerals, from 25 to 40 percent. Most of the mica occurs in the coarsely crystalline augen ores; the least fluorite, and mica to a great degree, in the finely crystalline varieties of massive ores.

In the coarsely crystalline augen ores, fluorite occurs as oval lenticular grains, measuring up to 1 cm in diameter. The long axes of the grains are usually parallel. The color of the mineral is a violet of varying intensity. The grains of fluorite seem to be bordered by light-colored, greenish or grayish, finely crystalline aggregates of muscovite, tourmaline, and phenacite. In the finely crystalline varieties of the ores, grains of fluorite are as small as a thousandth of a millimeter. In these ores, fluorite forms with silicates microaugen, columnar, subgraphic, micrographic, and rhythmically banded growth structures; the first three types of structure are most characteristic of the massive ores, and the latter two of the finely banded ores.

The mica minerals occur as fine scaly aggregates cementing the fluorite grains or forming thin intergrowths with them. The undivided mica crystals are almost completely indistinguishable from each other in external aspect, and are distinguished by refractive index and chemical composition, indicated by chemical analysis of the ore. Comparison of chemical

analyses of various ore specimens shows that the phenacite-muscovite and chrysoberylephesite ores differ sharply from one another in silica and alumina content. The relative atomic proportions of aluminium and silicon equal approximately 1 in the muscovite varieties of the ores, which agrees most with the atomic proportions of aluminium and silicon in the muscovite formula. In the ephesite varieties, this proportion equals approximately 2, which is the ratio of the atoms of aluminium and silicon in the formula of the brittle micas.

Muscovite and ephesite ores differ also in the ratio of the alkalies; in muscovite potassium is markedly predominant over sodium and, in ephesite, sodium predominates. Calculations made from the chemical analyses of the ores show that several varieties of the brittle micas occur. Ephesite is the one of these which has been established most precisely. Until final data for other brittle micas has been obtained, all ores with these minerals will be distinguished by the general name of ephesite-fluorite.

The results of chemical analysis of a mica vein containing about 35 percent muscovite and 65 percent brittle mica are given in Table 1. Investigations have shown that the mica is very near the ephesite from Postmasburg (South Africa), described by Koch [11], in chemical composition, optical properties, and lattice spacings. As is seen in the table, the ephesite from the Far East has about 30 percent of the margarite molecule corresponding to an approximate composition of 6.5 percent Na_2O, 2.1 percent Li_2O, and 3.7 percent CaO. Refractive indices are: Ng = 1.623, Nm = 1.620, Np = 1.591.

Besides ephesite, brittle micas, near margarite, and micas of intermediate composition between ephesite, margarite, and muscovite which possibly constitute a variety of the brittle micas as yet unknown in the literature, evidently also occur.

Phenacite in mica-fluorite ores and later veins consists of irregularly elongated prismatic grains, measuring from 0.1 to 0.5 x 3 mm. The elongated grains are often grouped into columnar aggregates, dimensions of which may be 1 cm in individual cases. In replacement ores, phenacite is associated with fluorite, muscovite, and tourmaline. Judging from the mutual relations of these minerals, the phenacite crystallized almost at the same time as the fluorite and earlier than the muscovite and tourmaline. In later apophyses, phenacite is most often associated with tourmaline and apatite, when all three minerals occur in approximately equal amounts.

The optical properties from replacement ores and veins are identical: Ng c, uniaxial, positive, Ng 1.668, Np 1.651. Results of computation from X-ray powder photographs of the mineral agree almost precisely with the data published. A specific feature of the phenacite of the fluorite deposits is the presence in its spectrograms of the clear band of beryllium fluoride. It can be supposed from this that the phenacite studied is a fluorine-containing variety of the mineral.

Chrysoberyl develops in varieties of ores unsaturated with silica, for which the presence of brittle micas and sometimes corundum is characteristic. In replacement ores, chrysoberyl grows in intimate association with fluorite, mica, and tourmaline and cannot be distinguished from them macroscopically. In one of the ore manifestations, mica-chrysoberyl veins, in which the chrysoberyl consists of fairly coarse (up to 1 cm), thick, white individuals easily discernible to the naked eye, occur.

Microscopic examination shows that chrysoberyl forms aggregates of isoterminal grains, rounded and rhombic in form, measuring from 0.01 to 0.15 mm. A characteristic feature of the grains is that they consist of six segments which extinguish in pairs. In transmitted light, the mineral is transparent and colorless, often contaminated with powdered inclusions of an opaque brownish material, resulting in a dingy-brown color and less transparency.

Spectral analyses of chrysoberyl taken from veins show a constant presence of tin, tungsten (around 0.1 percent), and niobium (0.001 percent). The tin content, according to chemical analysis, reaches 0.8 percent SnO_2. It is possible that these traces are due to the presence of finely dispersed inclusions of cassiterite and wolfram in the chrysoberyl, and that these explain the dirty-brown tint of the mineral in transmitted light.

The crystallization of chrysoberyl took place at almost the same time as the separation of fluorite and mica.

Cassiterite is seen fairly seldom in mica-fluorite ores. It can be seen more often in thin sections of muscovite veins cutting replacement ores. In both the ores and veins, cassiterite consists of single rounded grains and short prismatic crystals, measuring at least 0.1 mm. Coarser grains of cassiterite in the form of small lenticular segregations are encountered at the contacts of mica-fluorite ores with topaz greisens. In transmitted light, cassiterite has a very rich cinnamon tint, which masks its natural interference colors.

To conclude the characteristic features of the mica-fluorite ores, the spatial and genetic relationships of their muscovite and ephesite varieties must be dwelt upon. These relationships can be most clearly traced on the north-

TABLE 1. Results of and calculations from a chemical analysis of mica vein

Composition	Weight (%)	Molecular amounts		Ephesite			
		Muscovite	Ephesite	Atomic quantities of oxygen	Number of atoms of oxygen	Atomic quantities of cations	Number of atoms of cations
SiO_2	35.78	2616	3341	6682	4.07	3341	2.04
TiO_2	Trace	--	--	--	--	--	--
Al_2O_3	45.90	)	)				
B_2O_3	0.24	) 1308	) 3252	9756	5.94	6504	3.96
Fe_2O_3	0.34	)	)				
CaO	2.44	--	443	443	0.27	443	0.27
MgO	0.13	--	32	32	0.02	32	0.02
Li_2O	1.37	--	458	458	0.28	916	0.56
Na_2O	4.26	--	687	687	0.42	1374	0.84
K_2O	4.11	436	--	--	--	--	--
H_2O^+	5.22	872	2028	2028) 1538	0.94	3076	1.88
F	0.40	--	210	210	0.12	210	0.12
H_2O^-	0.12	--	--	--	--	--	--
	100.31			20296 -490 19806	12.06		
$O=F_2$	-0.17			-105	-0.06		
	100.14			19701	12.00		

Analysis by M. E. Kazakova
Common denominator: 19701 : 12 = 1642
Formula of ephesite: $Na_{0.84}\ Li_{0.56}Ca_{0.29}\ Al_2\ [Al_{1.96}Si_{2.04}O_{10}]\ [OH_{0.94}F_{0.06}]_2 \cdot O \cdot 3H_2O$.

ern edge of a pipe ore body, where among slightly altered limestones is seen a network of comparatively narrow (a few millimeters to a few centimeters in width) separate metasomatic zones which have evidently been formed under gentle tectonic conditions with slow infiltration of the solutions along a system of fine fissures. Thin mica veins are usually found in the central parts of these zones and are bordered on both sides by bands of fine-grained mica-fluorite rocks replacing limestones. Detailed microscopic study of the veins and enclosing rocks makes an interesting metasomatic zoning apparent: at the contact with veins, which consist mainly of ephesite, are situated zones of ephesite-fluorite rocks with chrysoberyl and corundum, alternating away from the veins with zones of muscovite-fluorite composition. The muscovite-fluorite zones have a sharp, sinuous contact with the limestones, in which the replacement of the primary calcite by fluorite and mica is clearly seen. The transitions between the muscovite-fluorite and ephesite-fluorite zones are also fairly sharp, although they are not marked by any definite boundaries.

The development of this zoning is evidently explained by the fact that silica diffuses more quickly into the limestones from the solutions than does alumina. This is the cause of the relative increase in concentration of alumina in the interstitial solutions in the vicinity of the ore-feeding fissures and the marked predominance of silica over alumina away from them. This phenomenon has much in common with the metasomatic desilication of skarn zones by diffusion described by Korzhinsky [3] and could be called metasomatic zoning by desilication of mineral-forming solutions.

This regularity of behavior makes it easy to explain the almost constant common occurrence in ore bodies of phenacite-muscovite and chrysoberyl-ephesite varieties, and also the absence of beryl in the ores. This mineral should separate at high concentrations of both silica and alumina and, during metasomatic zoning by desilication in carbonate rocks, mineral formation takes place either when the alumina is definitely deficient or relatively predominant over silica.

The topaz-fluorite ores usually form a series of irregular lens-shaped bodies, located along the contact of the mica-fluorite ores with granites, which have been converted into quartz-topaz greisens. The topaz-fluorite ores cement and replace shattered topaz greisens and mica-fluorite ores. Often a dense network of thin topaz-fluorite veins cutting and replacing the quartz-topaz greisens are seen on the underside of the topaz-fluorite ores. The thickness of the zones of secondarily altered greisens reaches 30 or 40 m, the intensity of metasomatism weakening with increasing depth. The intersecting veins of topaz-fluorite ores are traced for considerable distances on both sides of the contact, and also occur with the mica-fluorite ores.

The mica-fluorite ores form small bodies among the topaz-fluorite ores in the upper parts of a deposit directly at the contact of greisened granites and ores.

The transitions between topaz-fluorite and diaspore-fluorite ores are gradual, and, macroscopically, they are almost indistinguishable from one another. They are compact or finely crystalline rocks of a light color with a lilac or gray tinge, with a massive or thin-banded texture. The fluorite content is 40 to 50 percent; of topaz, 60 percent; and of diaspore, 40 percent.

Light micas and tourmaline also occur in these ores in insignificant amounts. The structure of the topaz-fluorite ores is of a collomorphic character. The main mass of topaz consists of microspherulites in which individual grains cannot be distinguished even at the highest magnifications. The sizes of the microspherulites varies from some microns to 0.5 mm. Fluorite forms granular aggregates and isolated grains, sometimes with idiomorphic outlines, included in a mass of topaz and also in a segregation of irregular form, growing in association with microspherulites and very fine little needles of topaz. From the topaz segregations thin meandering veins often branch off, intersecting the cryptocrystalline mass of topaz and having blind terminations. Diaspore is dispersed in the mass of fluorite and topaz as irregular, rounded prismatic grains measuring from 0.01 to 1 mm.

The statements given provide a foundation which enables us to consider that the deposition of the diaspore-topaz-fluorite ores is connected with a relatively late stage in the metasomatism, and is a consequence of the loss of alumina from greisened granites and its reprecipitation in crush zones and in open fissures, where a sharp change in the character of the solutions takes place with a rapid precipitation of the compounds dissolved in them.

The formation of the mineral complex which has been described and which is characterized by an almost complete absence of quartz and a wide development of minerals unsaturated in silica, and even quite deprived of it, indicates that the process of ore deposition took place under an overall deficiency of silica from solutions which have been primarily impoverished in silica (desilicated). These solutions obviously had quite high mobility, otherwise it would be difficult to explain the formation of such wide mineralized zones in the presence of the ore-feeding fissures which although numerous are very thin and often capillary.

On the other hand, it is difficult to visualize that the scalloped thin-banded mica-fluorite and topaz-fluorite veins with fairly typical collomorphic structures had been formed by deposition of material from solutions in which ions were dispersed in the normal way. It can be supposed that in the crush zones, under conditions of suddenly lowered pressure, and sometimes also of intense chemical reaction of the solutions with the limestones, these initially very mobile normal solutions, suffered vigorous evaporation of the solvent, cooling and supersaturation, and were converted into gels, from which were formed both the mica-fluorite and the topaz-fluorite and the scalloped thin-banded ores.

The syngeneticity of the greisens and mica-fluorite ores allows the latter to be regarded as special desilicated greisens, which have developed by replacement of limestones by fluorine solutions which had been impoverished in silica. It seems expedient to us that metasomatic rocks of similar type, in distinction to normal greisens should be named paragreisens, that is, rocks which are near greisens in composition and occurrence, but formed by the replacement of a sedimentary rock.

THE TOURMALINE-FLUORITE TYPE OF ORE DEVELOPMENT

The tourmaline-fluorite type of ore development is located in the exocontact zones of leucocratic granitic masses forming sloping pipelike bodies. They have been formed by the metasomatic replacement of limestones and skarns. This type is divided up into three subtypes: microcline-fluorite, tourmaline-fluorite, and sulfide-quartz-fluoride ores.

The microcline-fluorite ores are the earliest in comparison with the other subtypes. The following minerals (in order of decreasing amounts) enter their composition: fluorite, microcline, tourmaline, phenacite, apatite, muscovite, quartz, cassiterite, pyrite, and arsenopyrite. Outwardly, the microcline-fluorite ores consist of fine-grained rocks with more or less clearly expressed fine-banded texture, due to the alternation of thin light bands built up mainly of fluorite and microcline and dark-colored bands essentially tourmaline. Sometimes a brecciated texture is also seen in these ores, when the light thinly banded mass of fluorite and microcline with subordinate tourmaline seems to cement angular portions built up mainly of tourmaline. The origin of this structure is obviously due to the deposition of the ores by replacement of contorted tectonites containing fragments of rocks of different composition.

The tourmaline-fluorite ores are the most widespread types which are richest in tin and beryllium. Their relative age is established by the fact that they are clearly cut by tourmaline-fluorite veins. Outwardly, the ores are of fine-grained rocks of a light grayish-green tint and consist of pale-violet fluorite and green tourmaline. Besides the fluorite and tourmaline, the ore contains cassiterite, phenacite and a little pyrite, muscovite, and quartz. Sellaite is encountered in some varieties of the ores. The scallop-banded and concentric-zoned texture is characteristic of these ores and is due to rhythmic alternation of thin bands of essentially tourmaline and fluorite. The structure of the ore is fine-grained, consisting of radial spherulitic segregations of tourmaline and phenacite. It can be supposed that the ores with the concentrically zoned texture were formed by filling the opened cavities with colloidal solutions. The tourmaline-fluorite ores with massive and coarse-banded texture were formed by the replacement of tectonites, quartz-tourmaline rocks, and skarns.

The sulfide-quartz-fluorite ores are distinguished from the earlier first two subtypes of fluorite ores by the increased content of quartz and sulfides, an insignificant content of beryllium and the almost complete absence of cassiterite. Two varieties of the ores are separated by the mineral composition: quartz-fluorite with an insignificant content of sulfides, and arsenopyrite-fluorite. Outwardly, both varieties are fine-grained rocks of greenish-gray tint with a coarse-banded texture due to alternation of bands which are essentially fluorite, sometimes variegated in color, with bands impoverished in quartz or arsenopyrite. Besides the minerals enumerated, muscovite, pyrite, tourmaline, beryl, apatite, and chlorite (in order of decreasing amount) enter into the composition of the ores.

First-generation phenacite in the microcline-fluorite ores occurs as aggregates of milk-white grains of irregular rhombohedral and short prismatic forms, measuring some hundredth parts of and up to 1 mm. Phenacite accompanies fluorite, tourmaline, microcline, and apatite, but is the earliest mineral to separate.

A much later phenacite from the tourmaline-fluorite ores forms, for the most part, radial sheaflike or spherulitic aggregations built up of very weakly individualized columnar or acicular crystals. The size of the individuals varies from one hundredths to 3 mm. Single crystals occur infrequently. They have the form of little hexagonal prisms up to 1 mm in length. The color of the mineral in the ores is yellowish white.

Second-generation phenacite grows in association with tourmaline, fluorite, and cassiterite. Well-formed crystals of tourmaline are idiomorphic in relation to phenacite and sometimes weakly corroded by it. Very interesting are thin intergrowths of radial spherulites of

phenacite and tourmaline, with vague indistinct outlines of the individual grains and spherulites. The formation of these spherulitic structures is possibly due to the precipitation of material from gels. Fluorite is cemented by radial segregations of phenacite, but is xenomorphous to well-formed crystals of it. Cassiterite apparently crystallized later than phenacite, for little chains of fine grains of cassiterite are often situated at the grain boundaries of the phenacite in the spherulites.

Chemical analysis of phenacite from tourmaline-fluorite ores, by L. Ya. Vinogradova, gave the following results (in percent weight): SiO_2 = 54.30; BeO = 43.73; $Al_2O_3 + Fe_2O_3$ = 1.53. In optical properties and powder photographs both generations of the mineral are identical and near the phenacite described in the literature.

Cassiterite in microcline-fluorite and mica-fluorite ores consists of rounded, stumpy prismatic grains which sometimes form geniculate twins. The twins of the individual grains varies from a hundredth to one tenth part of a millimeter, concoctions of grains reaching 1 mm. Often the cassiterite is arranged in chains drawn out parallel to the banding of the ore. In transmitted light, cassiterite has a dense chestnut-brown tint, masking the mineral's interference, and muscovite in which it is xenomorphous to fluorite and idiomorphic to tourmaline and muscovite.

In the tourmaline-fluorite ores, cassiterite forms isometric grains and short prismatic crystals of a dark-brownish cinnamon color, measured in tenth parts of a millimeter, rarely up to 1 mm. Single grains and groups of them are fairly uniformly dispersed through the rock, nestlike segregations are not characteristic and are met in single cases. In thin sections, cassiterite has a light-brownish yellow or reddish-brown, sometimes patchy, tint and its usual interference colors. Geniculate twins are often seen. Cassiterite grows with fluorite, tourmaline and phenacite, and is the last mineral to separate.

In the central parts of the concentrically zoned formations, in association with microspherulitic tourmaline, cryptocrystalline cassiterite measures a hundredth of a millimeter and is a very dense-brown tint in transmitted light.

CONCLUSION

The tin-beryllium-fluorite ore developments and the topaz greisens and veins accompanying them are usually associated with masses of leucocratic granites and hybrid rocks chiefly of alkaline composition (monzonites, syenites, and others).

These ore developments are clearly differentiated by their chemical and mineral composition and the conditions of formation of all the deposits of tin, beryllium, and fluorite which have been described in the literature, and can be separated into a special ore formation.

The considerable differences in composition of the tin-beryllium-ore development in comparison with the deposits of cassiterite-quartz, intermediate and cassiterite-sulfide formation associated with them in time and place, cannot be attributed only to the action of the enclosing rocks or to the different stages of a single ore-forming process, but is the result, as it seems to us, in the first instance, of difference in source of the ore-forming solutions.

It can be supposed that the center of accumulation of carbonate rocks at depth in the granitic magma which produced the intrusions of hybrid rocks and leucocratic granites was the source of the desilicated solutions enriched in fluorine and boron. The ore development of cassiterite-quartz-tourmaline and sulfide-tourmaline-quartz composition (intermediate formation) is due to centers of accumulation of sedimentary rocks mostly of alumino-silicate composition in the granitic magma. The standard cassiterite-quartz ore development was formed from solutions whose source was obviously the uncontaminated intrusions of leucocratic granites.

These suppositions are, of course, only very preliminary and form a general hypothesis, requiring for its proof an additional array of factual material, especially data on the composition of the substance of the enclosing sedimentary rocks. It is possible that the attainment of these new data will make it possible to explain the as yet not understood causes why so special and complicated complexes of ore development should arise in some ore regions without analogy among any described in the literature. At present, only individual deposits more or less similar to one or other of the cassiterite-beryllium-fluorite types of formation are known.

Among foreign deposits, the nearest to the Far Eastern cassiterite-beryllium-fluorite ore development, are the ore bodies of the districts of Cape Mountain and Lost River of Seward Peninsula, Alaska. In the Lost River district, drilling has recently revealed [9] a vast and strongly mineralized granitic cupola among Silurian limestones. This blind ore body contains considerable reserves of tin-tungsten ores, of which more than 2 metric tons of the tin ores contain 18 to 20 percent fluorite. The presence of beryllium in the ores has been confirmed by spectrographic analyses.

The quartz-muscovite-topaz veins and greisens with beryl, cassiterite, and wolframite, and also the comparatively scanty cassiterite deposits of the topaz-tourmaline type to which

belong the deposits of the Sherlova mountain in Zabaykal'ye [5] and Mount Bishoff in western Tasmania [12] correspond to the cassiterite-beryllium-fluorite type of ore formation. The widespread development of topaz and the slight content of fluorite in these deposits and also other features which distinguish them from the cassiterite-beryllium-fluorite deposits are, to a considerable degree, attributable to the fact that the ore process apparently took place here in an alumino-silicate medium with a complete absence of carbonate rocks.

The character of the medium in which the ore formation takes place is seen to be an especially strong influence on the composition of the metasomatic rocks, including greisens, formed around the ores.

Features of the greisenization of granites and other alumino-silicate rocks have been discussed in a succession of papers, among which must first be mentioned the articles by Levitsky [4, 5], Chukhrov [10], Korzhinsky [3], Grigor'yev [2], Nakovnik [6].

Summarizing the conclusions of these investigations and not touching upon any other disputed questions, the following distinguishing features of normal greisens and greisens which have been formed by the replacement of carbonate rocks can be noted:

1. Greisens which have been formed by the replacement of granitoids are characterized by three main mineral facies: alumino-silicate quartz (mica-topaz-tourmaline varieties of quartz-bearing greisens), quartz and fluorite-quartz. Quartz is the predominant mineral of these facies: mica minerals are muscovite, biotite, zinnwaldite, lepidolite, siderophyllite: ore-bearing minerals are cassiterite and wolframite, rarely beryl.

The main mineral facies of greisens formed by replacement of limestones are alumino-silicate-fluorite, consisting of mica, tourmaline, feldspar, and rarely topaz and diaspore varieties of fluorite-bearing rocks. In some cases quartz-fluorite greisens can also be developed [1].

Fluorite therefore takes the place of quartz in lime paragreisens and so often clearly shows the overall undersaturation of the rock in silica. Among the mica minerals, besides muscovite, distributed in these rocks are ephesite, margarite, and also other varieties of brittle micas, and the ore components, including beryllium minerals (phenacite, chrysoberyl) and cassiterite.

2. Specific features of the chemistry of the process of greisenization of carbonate rocks, which distinguish it effectively from the process of formation of greisens from rocks of granitoid composition, is the marked introduction by postmagmatic solutions of alkalies, silica, and alumina; the loss of more or less of the calcium; and the almost complete removal of carbonic acid.

The alkalies, especially sodium, are known to be extracted intensively during the greisenization of granitoid rocks but the total amount of silica and alumina varies comparatively little, although in individual cases, an effective addition or loss of these components is possible.

In the greisenization of limestones, just as in normal greisenization, fluorine, boron, water, and a series of rare metals are introduced along with the alkalies, silica, and alumina. The introduction of fluorine is especially marked and evidently is to be attributed to the exceptional capacity of limestones to fix this element.

The development of different types of metasomatic zoning in the greisen bodies is controlled by the different chemistry of the greisenization processes in granites and limestones for greisen formed by the replacement of granites; zoning due to the extraction of alkalies from the original rock in the vicinity of fissures by acid hypogenic solutions is characteristic. By circulating in a carbonate medium, these solutions should obviously acquire a neutral, and then an alkaline, character. This, with the specific composition of carbonate rocks, makes impossible the growth in them of such regular and complete zoning by the extraction of alkalies, as in the granites. It can be supposed that the diffuse metasomatic zoning due to desilication described above is more characteristic of greisen in limestones.

4. The mica-fluorite and tourmaline-fluorite ores of the deposits differ essentially from the topaz-quartz and mica-quartz greisens associated with them by the wide distribution of beryllium minerals. This fact can be explained by referring to Korzhinsky's hypothesis [3] of the interaction of Cations in solution and an increase in their activity coefficients with increased total alkalinity of the solutions. When limestones are greisenized, the calcium in the rock controls the increases in the activity coefficients not only of the alkalies, but of beryllium as well, thus increasing its capacity to deposit them from the solutions. Carbonate rocks are therefore, other conditions being equal, an obviously more favorable medium for the formation of metasomatic deposits of beryllium, especially when contained in small amounts in the ore-forming solutions, than the acid alumino-silicate rocks. Conformation of this is the very widespread occurrence of isomorphic replacement by beryllium and of beryllium minerals in skarn formations.

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BRIEF COMMUNICATIONS

ON THE AGE OF COAL-BEARING DEPOSITIONS IN THE TRANS-BAIKAL

By A. A. Azarov

Some remarks by B. A. Ivanov on G. G. Martinson's ideas concerning the age of the Trans-Baikal coal measures were published in the "Critique" section of the Izvestiya of the Academy of Sciences USSR, Geologic Series, No. 6, 1956. The present paper contains new data corroborating the age difference in the Trans-Baikal coal measures.

B. A. Ivanov [1] considers all of the Trans-Baikal coal measures to be Lower Carboniferous. The reference in the subject paper to an earlier work [2] in which B. A. Ivanov, according to its author, regarded only the main coal body as Cretaceous, is unfounded. Ivanov had studied the older continental deposits [1], but, according to his own data, they are barren.

Martinson contends that the process of coal accumulation, in the same depression (the Gusinoozerskaya, Tarbagataiskaya), lasted from the Middle Jurassic to the Lower Cretaceous. Martinson's maps do not contradict the new data on the stratigraphy of the continental coal measures. They supply a more correct answer to the problem of the age of the coal measures.

A separation of stratigraphic units in a section can be accomplished by comprehensive analysis of geologic data, but the age determination of a sedimentary complex is established by means of paleontological and phytological data, as is done in Martinson's paper.

The fact that the Trans-Baikal coal measures are of different ages, and that the coal accumulation took plate in both the Jurassic and the Cretaceous, is indisputable.

Certain data gathered during field work on several coal sites in the Trans-Baikal area are applicable at this point.

In the Tamchinsk area of the Gusinoozerskaya depression, the Upper-Jurassic-Lower Cretaceous age is suggested by the flora-fauna complex. Besides the forms described by Martinson [3], it includes the following fauna: Unio sp. (cf. menkei) Dunk., Cyrena Sibirica Ramm.; and the following flora: Onychiopsis elongata (Geyl.) Jok, O. tenuissima Pryn., O. Mantellii Brongn., Coniopteris obrutschewii (Krasser) Pryn., C. angarensis Pryn., Sphenopteris sp. ex gr. Rufforidia goepperti Dunk., Sc. tarbagataica Pryn., Sc. dahurica Pryn., Equisetites sp. cf., Eq. ferganensis Sew., Phyllotheca sp. cf., Ph. sibirica Heer, Anomozamites sp., Podozamites Eichwaldii Heer, Ginkgo digitata Brongn., G. sibirica Heer, Sphenobaiera angustiloba (Heer) Florin, Phoenicopsis angustifolia Heer, Feildenia ensiformis Heer, Pityophyllum Nordenskioldii Heer, Elatides sp., Stenorhachis sp., Ixostrobus (Heer) Pryn. (fauna identification by Martinson; flora by Genkina).

The Middle Jurassic of the coal measures of the lower part of the Tugnui depression section is suggested by the following fauna and flora: fauna: Ferganoconcha sibirica Tschern., F. cf. estheriaeformis Tschern.; flora: Coniopteris sp. cf., C. obrutschewii (Krasser) Pryn., C. Maakiana (Heer, Pryn., C. Burejensis (Zal) Sew., Cladophlebis sp. cf., Cl. argutula Heer, Cl. sp. cf., Cl. whitbiensis Brongn., Cl. sp. cf., Cl. lobifolia Phillips, Raphaelia sp. cf., R. diamensis Sew., Podozamites lanceolatus (L. et H.), Czekanowskia rigida Heer, Confervites sp., Pityoptyllum Nordenskioldii Teer., Taxites sp., Pityophyllum Lindstromii Nath., Elatides sp. cf., El. ovalis Heer.

The horizons, stratigraphically higher in the Tugnui depression section, may be referred to the Upper Jurassic on the basis of Pseudocorbula jurassica nov. gen., nov. sp.

All age determinations for the coal measures are based on the assumption that the generic content of the flora changed only slightly during Jurassic-Upper Cretaceous time. Even such species as Sequoia Smittiana Heer Bukachachinskaya, Nerchuganskaya depressions) apparently originated as early as the Middle Jurassic.

Thus, the onset of coal accumulation throughout the Tugnui depression took place in the Middle Jurassic, rather than in the Lower

Cretaceous, as is stated by Ivanov (1).

Many new data on the age differences of the Trans-Baikal coal measures have been accumulated recently. The study of the fresh-water Ferganoconcha fauna from the coal measures, undertaken by Martinson, is a great step toward clarification of the stratigraphy of these extremely complex continental deposits.

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ON THE SANTONIAN DEPOSITIONS IN SOUTH-WEST CRIMEA

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The deposits of the southwestern Crimea, usually considered Santonian [1, 2, 3, 5], are best developed in the Bakhchisarai and Kuibyshev areas. Near Bakhchisarai, between the rivers Kacha and Bodarka, the following section is observed:

Cr_2^{cmp} 1. White chalk-like marls.

Cr^{snt} 2. White chalk-like limestones with layers of kile (fuller's earth) and veinlets of black chert; thickness, 12 m.

3. Light-gray marls, locally siliceous; thickness 23 m.

4. Light-gray marls alternating with greenish-gray marls; thickness 18 m.

5. Light-gray sandy marls and limestones; thickness 12 m.

6. White limestones with stylolites; thickness 12 m.

The overall thickness of the Santonian deposits in the Bakhchisarai area is 65 m.

The Santonian deposits along the rivers Bodarka, Kacha, and Bel'beka are lithologically similar.

These areas differ in the character of the contact of the Santonian deposits with the underlying rocks. Along the river Bodarka, this contact is sharp, but uneven, with rhyzoliths in the underlying rocks. Slight erosion, possibly submarine, occurred here. In the Kacha river basin, the contact is less distinct but still sharp.

Along the Bel'beka river, a gradual transition is observed at the contact. In the areas where the contact is sharp, horizon 5 is represented by sandy rocks (see cross-section), while in the Bel'beka area this horizon is composed of pure limestones.

These deposits contain scarce, poorly preserved remains of Inoceramus, sponges, and echinoids of the Santonian. A number of Actinocamax verus Mill were found recently in horizon 4 of the Bakhchisarai area. Remains of Marsupites occur in horizon 5, along the rivers Kacha and Bel'beka. The Santonian deposits can be subdivided into two groups by use of the numerous, minute foraminifera: the lower, comprising horizons 5 and 4; and the upper, corresponding to the horizons 3 and 2.

The lower group contain Anomalina umbilicatula Mjatliuk, A. infrasantonica Balakhmatova, Stensioina exculpta (Reuss), Gyroidina turgida (Hagenow), Globotruncana ventricosa White, G. lapparenti Brotzen, and others. This assemblage characterizes the lower Santonian horizons of the Russian Platform and the Crimea-Caucasus region.

The upper group contains such groups as Anomalina clementina (Orb), A. stelligera (Marie), O. costulata (Marie), and others, known from formations usually correlated with the Upper Santonian.

The underlying horizon 6, in the sections along the river Bel'beka, is characterized by a foraminiferal assemblage considered to be of the Coniacian stage.

Of interest is the discovery of crinoid calyx plates of genus Marsupites Mantell in the Crimea. At present a single species of this genus is known, which, by the priority rules, should be named, M. testudinarius Schlotheim.

Sieverts 4 has shown that this species includes forms with smooth, wrinkled, and transitional plate surfaces. She contends that all other species separated on the basis of these differences are synonyms for M. testudinarius, and should be abandoned. Of the numerous synonyms for this species, M. ornatus J. Miller should be mentioned (Sowerby, often and erroneously, is thought to be the author of this species). In North America, its synonym is M. americanus Spangler.

The plates found in the Crimea belong among the smooth forms. They resemble those illustrated in Sieverts' paper (4; Table 1, Fig. 1).

Marsupites testudinarius Schloth. is widespread and typical for the upper portion of the Santonian deposits of northwestern Germany, England, Ireland, France, Poland, Northern Africa, North America, India, and Australia. In the West European usage, a separate Marsupites zone is designated.

Thus the micropaleontological data and occurrence of M. testudinarius confirms the Santonian age of horizon 5. It is of interest that our data shows this genus occurring at the base of the Santonian of southwestern Crimea.

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FROM THE HISTORY OF GEOLOGIC SCIENCE

by

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MEMORABLE DATA FOR JANUARY-MARCH 1958: REVIEW 20. TRICENTENARY OF THE SECRET OFFICE

In 1658, the Secret Office was created to eal with a number of problems, among which nining was prominent. The first department f the Secret Office dealt primarily with the roduction of building stone, salt, and other seful minerals. The second department irected the "search for several ores and eposits," and coordinated all problems of ex- loration. Great care was taken in the selec- ion of experienced miners, and men were in- ited to Moscow to serve the State not only rom its various principalities but also from broad.

Expeditions were dispatched to search for old, silver, copper, iron, mica and saltpeter. 'hus, in 1663, Maxim Nashchokin was sent to ne Pskov area to search for saltpeter, and in 666, a search for copper was carried out un- er the direction of Semyon Gavrilov in the lonetsk area. In 1672, section chief (Stolnik) enedikt Khitrovo, assistant clerk (Podyachii) nd Eremei Polyanskii, were exploring the erkhoturye (Upper Tura) area. In 1673, the liloradov brothers and Klim Nekrasov were ommissioned to search for silver along the lezen and Kevral rivers. In the same year, heriff (Posadskii) Erofei Danilov was com- nissioned to "go from Nijnii (now Gorki) to erm and search for silver and any other ore, nd report all findings to the Secret Office." n most cases, the Secret Office initiated the xplorations for ore and outfitted the expedi- ons. Local administrations were ordered to ive all possible assistance to the explorers nd the "ore-searching" teams were usually nanced locally, although occasionally the ecessary monies were assigned by the Office.

The explorers were instructed to report eriodically to the Office on the progress of neir work. In some cases, special instruc- ons were given as to procedure. Thus, the nstructions that were given to Colonel Gustav ampen in 1673 to investigate the "alabaster nountain," located about 100 miles from Ark- ngelsk, specified that he should "look into, escribe, and set it forth on a drawing." Moreover, he was instructed to search for gold, silver, and other ores.

The Secret Office continued for about 20 years, and accomplished a number of important explorations. It was abolished in 1676, and its functions were taken over by the Cannon (Pushkarskii) and Siberian Offices.

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THE 250TH ANNIVERSARY OF THE BIRTH OF I. A. SCHLATTER

Ivan Andreevich Schlatter was born in Berlin on February 19, 1708. In 1719 he went to Russia with his family. From 1722 on, Schlatter worked in the field of testing at the Berg-Kollegium.

Schlatter was active in metallurgy, minting, and mining. His new methods in the metallurgy of noble minerals and his authoritative publications gained him recognition and promoted his rapid advancement. He became President of the Berg-Kollegiu, and he held this post until his retirement, at his own request, in 1767.

Geology was among Schlatter's diversified interests. In his voluminous "Detailed Instructions on Mining" (1760), in four parts, there is a section on "Ore Sites, Veins, and the Search for Them," which is essentially a text on ore deposits. It contains data on methods of exploration, conditions of ore deposits and their forms. He notes that the main mineralization often occurs not in the vein itself but rather at its contact with the enclosing rocks. He also states that "the cross-cutting veins contribute much to the constancy of the ore."

The remaining three parts of this book deal chiefly with technical topics: the carrying out of mining, the development of ore sites, and ore enrichment. Only in concluding pages does he return to geological problems, dwelling especially on the features of coal measures

Schlatter cared little about purely geological problems, and his utterances unquestionably reflect the ideas of M. V. Lomonosov. He noted, for instance, that the sea had once occupied much of the present dry land, and that mountains had been formed as a result of earthquakes.

In setting forth his data on the features of ore sites, Schlatter displays considerable knowledge of the peculiarities of the weathering of sulfide ores. He also lists botanical and geomorphological criteria for recognition of ore sites. Describing this morphology of ore bodies, Schlatter separates them into three types - veins, tabular bodies, and stockworks - and correctly describes each type.

In speaking of methods of exploration, he recommended looking for outcrops in stream valleys, and panning river sands. He explained how pebbles and boulders could lead to the mother lode.

In his book, Schlatter took advantage of experience in ore exploration he had gained abroad as well as in Russia. With illustrations borrowed from western European editions, he introduced factual material on Russian ore sites.

In 1763 Schlatter published his translation of "Mineralogy" by the Swedish scientist I. G. Vallerius. This fundamental work became the first textbook of mineralogy in Russian.

I. A. Schlatter died on February 3, 1768.

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THE 175TH ANNIVERSARY OF THE BIRTH OF THE BELGIAN GEOLOGIST J. OMALIUS d'HALLOY

Jean Baptiste Julien d'Omalius d'Halloy was born in Liege, Belgium, on February 16, 1783. Upon completing his formal education, he went to Paris in 1801 where he attended lectures by G. Cuvier, A. Brogniart, A. Furcroix, J. Lamarck, and other outstanding French naturalists. In 1804, he undertook his first geologic investigations. During the next 10 years he traveled more than 25,000 km, visiting Belgium, different parts of France, the Pyrenees, the Alps, northern Italy, the Balkans, Austria, and Switzerland. Among his early works, of note is a paper (1808) on the geological structure of northern France, in which he first established the geological age of the local rocks. He was able to separate two systems, by their fossils, which later became the Jurassic and Cretaceous, and he correctly established their stratigraphic position. In the same work he emphasized that, in the study of mountain ridges, importance should be attached not to their form but rather to the position of their component beds.

In 1813, d'Halloy established the true tectonic scheme of the Paris Basin and refined its stratigraphy. In 1822, he offered one of the first variations of the single geochronological scale, which was used for some time in many countries.

In spite of a scarcity of reliable paleontologic and geologic data, d'Halloy was able to separate large new stratigraphic units. Thus, his time scale contained the "Peneen" beds, which he identified in 1808 as "red sandstones," and which were later correlated with Permian and Triassic deposits.

In the same stratigraphic scheme, the Cretaceous was introduced as a separate stratigraphic unit. From that time, the idea of Cretaceous "formation," or system, became firmly established; it was further studied by d'Orbigny.

"Eléments de Géologie," by d'Halloy, a monograph published in 1831, was very successful and ran through many editions. Considerable space was devoted to the structure of the earth's crust and to rock classification based on lithological and stratigraphic properties. However, on the basis of the latest developments in geology, d'Halloy subsequently revised his original scheme.

In 1816, d'Halloy was elected to membership in the Belgian Academy of Sciences, and he served as its president for three terms (1850, 1858, 1872). He was also member of the London Geological Society and a number of other institutions. In recognition of his work over extended areas of France, he was elected president of the French Geological Society in 1852.

D'Halloy died August 15, 1878.

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SESQUI-CENTENNIAL ANNIVERSARY OF THE BIRTH OF L. A. SOKOLOVSKII

Luka Aleksandrovich Sokolovskii was born on February 15 (3), 1808, into the family of a minor official. In 1827, he graduated from the Mining Cadet Corps and was sent abroad for further study. Upon his return, he was appointed to Altai where, from 1843 to 1855, he was the mining administrator first at the

Kolyvan-Voskresensk plant and then at the Altai plant. From 1853 until his death, he was a member of the Mining Council and of the Mining Learned Committee.

Sokolovskii was interested in various branches of geology. In 1830 he published the results of his observations along the Sablinka River near Petersburg. He pointed out that the indigenous rocks should be classified as Paleozoic and not Tertiary, the latter classification having been given to these rocks by the English geologist, G. F. Strangweiss, who regarded the clays that outcropped there as equivalent to "potter's clay."

In later years, Sokolovskii studied the gold and coal deposits of the Altai. He paid great attention to ore deposits, and studied the mineral composition of the ore and of the matrix rocks. As early as 1836 he was able to point out the changes that were taking place at the ore-rock contact; this was one of the first descriptions of contact metamorphism. Sokolovskii did not limit himself to a simple statement of his observations; he also suggested that, while exploring, special attention should be paid to secondary alterations in the sediments so that the ore veins which had caused such alterations could be discovered.

During his stay in the Altai, Sokolovskii assembled a large mineral collection. Since some of the specimens were of considerable scientific interest, they were studied by other investigators.

In addition to being one of the foremost miners, Sokolovskii was also known for his progressive opinions. During the 1850's, he actively campaigned for the abolition of serfdom, maintaining that this would promote industrial development.

He was active in the Mineralogical Society and was elected an honorary member in 1871. He died February 24 (12), 1883.

THE 125TH ANNIVERSARY OF A. L. CHEKANOVSKII

Aleksandr Lavrentevich Chekanovskii was born March 24 (12), 1833 in Kremenets, former Volynsk Province. He graduated from the Medical Faculty, Kazan University, in 1855, after which he attended lectures in mineralogy and geology at Derpt University for two years. As punishment for taking part in the Polish revolt of 1863, he was banished to Siberia. There he took up geologic investigations.

His early interest in geology had prompted him, while still a student, to write a paper on the granites of Volyn and Podolia, never published. In 1866, Chekanovskii began his work in the Angara basin; a year later, at the intercession of the Academy of Sciences, he was allowed to live in Irkutsk where he was active in the Siberian Department of the Russian Geographical Society. He prepared the first geologic map of the southeastern part of the Irkutsk Province, and for this map received gold medals from the Russian Geographical Society and the Paris Geographical Exposition.

During 1873-1875, he made three long journeys, covering a total of more than 25, 000 km, along the valleys of Nizhnyaya Tunguska, Olenek, Yana, and Lena from Yakutsk to the mouth. These expeditions provided very valuable material on the geology and geography of this practically unknown part of northern Siberia. His large paleontological collection of more than 400 specimens made it possible to refine the stratigraphy and areal distribution of deposits of different ages, and it became a subject of study by a number of experts. The data gathered by Chekanovskii became the basis of cross sections: latitudinal, from the Yenisei to the Lena, and meridianal from Baikal to the Arctic Ocean.

Chekanovskii's work earned him the right to move to Petersburg where, in the spring of 1876, he settled down to work on his collection at the Academy of Sciences Museum. He committed suicide on October 30 (18) of the same year.

A ridge between the Lena and the Olenek and a number of fossil animals and plants have been named for Chekanovskiy

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CENTENARY OF THE BOOK ON GEOLOGY OF THE URALS, by N. G. Meglitskii and A. P. Antipov

In 1858 the fundamental work by Nikolai Gavrilovich Meglitskii and Aleksei Ivanovich Antipov, "Geognostic Description of the Southern Part of the Ural Ridge, as Studied During 1854 and 1855" was published. This work is distinguished by its comprehensive approach, which enabled the authors to arrive at important conclusions concerning the stratigraphy, tectonics, history of development and geomorphology of the Urals. The book presents a successful attempt to relate relief with lith-

ology of the alternation of series, breaks and other tectonics peculiarities.

This detailed study of the relationship between relief and geology was a true morphological study, and unique in the middle of the nineteenth century.

Extensive paleontological collections enabled the authors to refine the stratigraphy of the South Urals. More specifically, the presence of Lower Silurian deposits was established, and it was shown that a considerable portion of the section thought to be Devonian by R. Murchison, was in fact Silurian. These views have only recently been accepted.

Younger formations are described in great detail in this book, especially Devonian and Carboniferous. Long lists of fossils are given, together with the exact distribution of small stratigraphic units.

The authors were among the first to describe the phenomenon of cleavage, and pointed out that it might be confused with bedding. Folding is explained as being due to a combination of lateral compression and vertical movements. Their work gives the first, and generally correct, tectonic scheme of the southern Urals. Being under the sway of the reigning theories of the vulcanists, the authors persisted in seeking a connection between positive structures and magmatism. They painstakingly studied the vast complex of effusives, and they outlined an essentially correct temporal scheme for manifestations of individual phases of magmatism throughout the South Urals.

In the width of the scientific horizon, and in the depths of generalizations, this book had no peer in the contemporary geological literature.

CENTENARY ANNIVERSARY OF E. V. TOLL

The outstanding polar explorer Eduard Vasilevich Toll' was born March 24, 1858 (12), in Tallino. He graduated from Derpt (Tartus) University in 1882, and soon undertook his first journey north, with the A. A. Bunge expedition to the Novosibirsk islands and the basin of the river Yana.

The geologic material collected by E. B. Toll supplied the first data on that vast region. He established the presence of Silurian, Devonian, Triassic, Jurassic, Tertiary, and Quaternary deposits. Parts of his collection he studied himself, establishing the presence of Devonian and Silurian fauna on Kotelny Island. The discovery of fossil flora in the Mesozoic and Tertiary deposits of that island was of great significance.

In 1887 he was appointed Curator of the Mineralogical Institute, Academy of Science and commissioned to go abroad. There, at a conference of German geographers, he read paper on the results of his first expedition. 1888-1892, commissioned by the Geological Committee, E. V. Toll carried on investigati in the Kurland, Petersburg, and Kovno Provinces. In 1889 he passed his Master's examination and joined the staff of the Geological Committee.

In 1893, the Academy of Sciences put him charge of the expedition to northeastern Sibe which was temporarily interrupted by the dea of I. D. Cherskii, its initial leader.

The observations by E. V. Toll yielded va geologic information and were the base for a paper reviewing the geologic structure of the Yana basin and Novosibirsk islands (1899). voiced the opinion that an ancient folded regi formerly occupying this area, had been denu and submerged. Only recently, small uplifts resulting in modern marine terraces occurre there.

The most important publication by E. V. T (1897) deals with fossil ice. He described it varieties and introduced the idea of fossil ice In studying the burial environments of mammoths, he concluded that they had lived in northern areas of Siberia as late as after the close of Quaternary glaciation, thus explaini why their remains rested in fossil ice preser since glacial times.

In studying and reclassifying the museum collections, E. V. Toll established the fairly large extent of the Cambrian and Lower Siluri (Ordovician) deposits throughout Siberia, and wrote a special paper on this subject (1895).

During his sojourn on the Kotelny Island, E. V. Toll sighted an unknown island lying to the north. As a result, an expedition by the ship Zarya was sent out under the leadership of E. V. Toll, in 1900. During the journey, h explored Bennet Island where he collected muc material and data which were recovered after the loss of the expedition. At the same spot, note by E. V. Toll was found, dated Nov. 2 (Oct. 20), 1902, which contained brief informa tion on the geologic structure of Bennet Island mentioning the finding of remains of large quadruped mammals and also the presence of fossil coals, under a mantle of basalt. These materials by E. V. Toll, carefully selected and well-documented, were subsequently worked over by a number of outstanding experts and gave an idea of the geology of the area. The fate of E. V. Toll has remained obscure. Apparently, he and his companions perished c their return trip to the Novosibirsk Islands, a the close of 1902.

A bay in the Kara sea, on the northwestern

shore of the Taimyr peninsula is named after E. V. Toll.

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SEVENTY-FIFTH ANNIVERSARY OF THE ACADEMICIAN M. A. USOV

February 20, 1958 is the seventy-fifth anniversary of the outstanding student of the geology of Siberia, Academician Mikhail Antonovich Usov.

Brief biographic and academic data on M. A. Usov are given in Izvestiya Akademiya Nauk SSSR, Ser. Geol., 1954, no. 4.

THE SIXTIETH ANNIVERSARY OF THE ESTABLISHMENT OF THE L. A. SPENDIAROV PRIZE

The prize named for the Russian geologist L. A. Spendiarov was established in 1897. According to the resolution, the award of this prize is to take place at each session of the International Geological Congress and the money is to come from the interest capital deposited in a bank by the father of Leonid Afanasievich Spendiarov - a participant in the Seventh Session of the MGC - who died opening day. The prize is to be awarded for the best work in geology completed before the current session. To adjudge the award, a commission is elected at the Congress, with a representative of our country as a mandatory member.

The first such award, by the Eighth Session MGC, in 1900, was presented to Academician A. P. Karpinsky, who declined it in favor of foreign scientists; it was then awarded to the Portuguese geologist, P. Choffa. On most subsequent occasions, the award was presented to a geologist of the host country. In 1903, it was given to the Norwegian geologist V. Bregger for his work in petrography (Ninth Session); in 1906, to F. H. Chernyshev for his "Upper Carboniferous Brachipods of the Urals and Timan" (Tenth Session); in 1910, to the American geologist I. M. Clark for his work, "Early Devonian History of New York and Eastern North America" (11th Session); in 1918, to French geologist E. Argan for his "Les nappes de recouvrement des Alpes occidentales." (12th Session).

The 13th Session adjudged no prize. At the 14th Session, in 1926, it was announced that the Soviet government had left the award funds at the disposition of the Congress, and its adjudgment continued at the 1929 Session when it was awarded to South African geologist L. T. Nell; it was awarded to American geologist T. B. Nolin (16th Session, 1933); to Soviet scientist V. P. Baturin (17th Session, 1937) for his work in petrography; to English petrologist L. P. Wedger for his exploration in the Himalayas and Greenland (18th Session, 1950); to French scientist G. Termier for his contribution to the geology of North Africa (19th Session, 1952); and finally to Mexican geologist Manuel Alvarez for his fruitful geological research in various parts of Mexico (20th Session, 1956).

THE FIFTIETH MEMORIAL OF G. C. SORBY, ENGLISH GEOLOGIST

Henry Clifton Sorby was born in 1826, at Woodborne, near Sheffield (Central England). While interested in various fields of natural science, he devoted his main efforts to geology. His most important scientific achievement was the development of microscopy in petrography. From 1842 on, he began to prepare thin sections of rocks and to study them in passing light, under a microscope. His paper on the microscopic structure of the Scarborough calcareous sandstones, published in 1851, attracted no attention, but he continued to apply and popularize his method. Microscopic analysis soon gained general recognition, thus heralding a new stage in the history of petrography.

G. C. Sorby paid much attention to the problems of sedimentation and to the study of sedimentary rocks. He took up the problem of "cone-in-cone" structure, was interested in the nature of chalk coccolites, in the conditions of the formation of concave pebbles, in the processes of denudation and in the formation of river terraces. He carried out mineralogical analyses of sedimentary rocks, particularly of such changes as result from psdudomorphic replacements by calcite and aragonite.

G. C. Sorby studied the nature of isomorphism and mineral coloring. In his study of meteorites, he used spectral analysis as well as the microscope, which made possible a detailed determination of their compositions. He also perfected the blowpipe method of mineral study.

In order to explain cleavage, G. C. Sorby conducted a number of experiments which proved that this phenomenon is brought about by pressure. His study of the microtexture of rocks enabled him to gather vast amounts of material on crystalline schists.

His contribution to science was rewarded by his election to the Royal Society (in 1857) and to many scientific societies of England and other countries. He was very active in them, as the first chairman of the Mineralogical Society (1876-1879), and in the Microscopical

Society (1875-1877), and Geological Society (1878-1880). He was awarded three medals for his scientific work. He died March 9, 1908.

THE TWENTY-FIFTH MEMORIAL OF D. V. GOLUBYATNIKOV
by V. V. Tikhomirov and T. A. Sofiano

Dimitrii Vasilevich Golubyatnikov, an outstanding oil geologist, was born in 1866, in the Don province. While a student in the Novocherkassk Real School, he joined the "Narodnaya Volya" (People's Will) party, organized a group of youths, and carried on revolutionary propaganda among the local workers and impoverished Cossacks. In 1883 he was arrested for the first time; a year later he moved to Petersburg and entered the Mines Institute. In 1886 he joined the combat group headed by A. I. Ulyanov, soon was again arrested and spent ten years in prison and in exile. He returned to Petersburg in 1897 to continue his education in the Mines Institute, graduating in 1900, and immediately went to work for the Geological Committee.

Nearly all of his later activity was in the field of study of the southeastern Caucasus oil deposits.

Of paramount importance were his stratigraphic studies. His review of previous paleontological findings made possible a telling refinement in the age determination of a number of series; it established a scheme of stratigraphic differentiation of the Baku petroliferous area, which has become a reliable basis for further geological study of the Apsheron peninsula.

A detailed cross-section of the productive interval, as constructed chiefly from lithologic data, made possible an immediate pinpointing of the tectonics of individual oil fields, in bringing to light the formerly unnoticed breaks, faults, etc.

Among the most important achievements of D. V. Golubyatnikov is the development of structural map-making which by then had become indispensable in geological exploration of oil areas.

Especially great is Golubyatnikov's contribution to the discovery of new oil deposits. For example, one of the largest oil fields, the Surakhany, originally had been thought to be a gas producer. However, D. B. Golubyatnikov proved its oil-bearing capacity and discovered its new and prolific extension, the Kara-Chukhura area.

D. V. Golubyatnikov is also credited with the discovery of other prolific oil fields of the Azerbaidzhan.

He believed in the presence of oil in the oth[er] parts of the Caucasus and did reconnoitering i[n] Georgia and Daghestan. He also familiarized himself with the petroliferous provinces of Ferghana (Uzbek SSR), northern Iran, and the Volga region.

His work was proof positive of the importan[t] part played by the geologist in the developmen[t] of oil areas, and has become the foundation of petroleum geology.

After the Great October Revolution, and up to 1922, D. V. Gulubyatnikov was active in the reconstruction of the Donets coal industry, and then returned to petroleum geology. In 1922 he became Professor of the Moscow Mining Academy, while still continu[-] ing his practical work and his exploration o[f] the Apsheron peninsula.

In his capacity of an outstanding collaborat[or] of the institutions then directing the study of fossil fuel supply, he was most active in promoting all measures to stimulate the oil industry of the U. S. S. R. He initiated electric well-logging as one of the methods of geological exploration for oil, as well as the geothermal study of oil wells. He attributed a great significance to the study of ground-waters throughout the petroliferous areas and pointed out the necessity of initiating special hydrological investigations. He is credited with the first attempt to an estimate of the oil reserves in Baku, as based on specific data on individual producing beds, rather than on general considerations.

In the course of his long activity, D. V. Golubyatnikov has created a new school of petroleum geologists.

He never broke his ties with the revolutionary movement: from 1906 on, he remained in contact with the Baku Bolshevik organization, and he joined the Communist party in 1924.

D. V. Golubyatnikov died January 2, 1933.

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REVIEWS AND DISCUSSIONS

CERTAIN GEOLOGIC-GEOGRAPHIC TERMS
by I. P. Kartashov

In his recently published paper [5], N. I. Nikolayev rightly points to a long list of shortcomings in geologic-geographic nomenclature. It is not to be denied that indeed "the time has come to review a number of terms now in usage" [5, p. 107]. In the order of discussion, I want to touch upon certain terms now in wide usage in the geologic-geographic sciences.

Nikolayev proposes the term, denudation, for "baring, carrying away from the surface of clastic material, as a result of various processes" [5, p. 107]. In geomorphology, denudation apparently should correspond to the lowering of the earth's surface as a result of several exogenous processes. Denudation, so understood, is opposite to accumulation - "accumulation of the products of disintegration, as a result of various external processes" [5, p. 107]; or, in geomorphology, a rise in the earth's surface as a result of such accumulation. Nikolayev emphasizes that, as he sees it, "both words are general terms applicable to any external (exogenous) processes [5, p. 107].

While fully concurring in the idea of expediency, even necessity, of such general terms, I want to point out that there is another term, destruction, for the process of breaking up of the rocks (their disintegration into loose material and their subsequent removal), which is manifested morphologically in a lowering of the earth's surface. Nikolayev mentions it in his paper, but evidently prefers not to use it. However, this term has certain advantages over denudation. First, its etymology (Latin destructio: breaking-up) is more in accord with the essence of the process than is the meaning of the term "denudation" (denudo: I bare). Second, although destruction is less common than denudation in geologic-geographic nomenclature, it has but one meaning - the one which Nikolayev proposes to designate as denudation. Now, "the understanding of denudation is not universal, at present" [5, p. 102], and its connotation given by Nikolayev does not seem to be the most accepted.

I proposed, then, to legalize the term destruction as a general term designating the destructive action of exogenous processes, while retaining another meaning for the term, denudation, which I shall take up later on.

In contrasting accumulation and destruction, it should be kept in mind that the former term is quite commonly limited to alluvium accumulation, regarding it as a process opposite to erosion. Such a narrow interpretation of the term should be abandoned. The interriver areas, presenting as they do a combination of highlands and slopes of variable steepness, are usually developed under the action of complicated exogenous processes. The initial stage of these processes is the break-up of indigenous rocks into loose material. This process has been called weathering Tr.: literal Russian meaning is "winding out", although there is hardly a single student who would call this term appropriate, since wind action has nothing to do with the process. It seems to me that disintegration is more appropriate in the designation of the transformation of rocks into loose material.

The distribution of loose material along the interriver slopes, and its subsequent removal, is accomplished by landslides and creep by the action of unchanneled streams (sheet erosion), and by solifluction, all activated by gravity. Field experience shows that, as a rule, these processes are so intermeshed that differentiation is practically impossible. This is particularly true for areas of mountainous relief. In such areas, a differentiation between the relief forms and the material deposited on the slopes by one of the above processes is virtually impossible. For instance, how is one to separate landslides, creep, and deluvia (sheet-flow deposits) of a mountainous area, if they have been formed at the same time and at the same spot?

A generalized term is needed for the practically indivisible complex of the processes of redistribution of the loose material over interriver slopes. It seems to me that one cannot get away from the fact that denudation has long been so used. As early as 1938, Yu. A. Bilibin

pointed out that "at present, it is more logical and more convenient to understand denudation to mean only a redistribution of clastic material along the slopes by gravity" [1, p. 66], the gravity being "assisted, more or less, by snow and rain waters, frost, temperature differences, and other factors" [1, p. 65]. It should not be forgotten that, as of now, there is no other word for an aggregate of these processes.

For this reason, it would be most expedient to let denudation remain as a general term for the combined processes of redistribution of loose material along interriver slopes: the landslides and creep, sheet erosion, and solifluction. It is true that solifluction sometimes dominates the others to the extent that it becomes paramount in the formation of specialized solifluction relief forms and deposits. It should be kept in mind, however, that the solifluction process (redistribution of material because of its alternate freezing and thawing) is present, to a greater or smaller extent, in areas where winter temperatures are below zero, including those where the typical solifluction relief forms and deposits are absent.

In using denudation in the proposed sense, it should not be forgotten that the processes of redistribution of the loose material along the interriver slopes do more than destroy those slopes and lower their elevation. An accumulation of loose material and a rise in the earth's surface, often take place at the lower reaches of those slopes - the process of denudational accumulation. To be sure, such a view of the denudation processes is somewhat at variance with the etymology of denudation. But there are quite a few instances when a meaning is read into a scientific term which somewhat slightly modifies its original meaning; this, then, should hardly be viewed as a basic drawback.

In presently accepted classifications, the deposits formed by denudation processes are divided into a number of genetic types. For instance, in Ye. V. Shantser's classification [4, p. 39], the slope deposit (colluvial) group includes, as genetic types, the slide and creep accumulations (dispersions), deluvium, solifluction (defluction) and slide accumulations (delapsia). In the classification by S. A. Yakovlev [4, p. 46], the slope deposits belong to different genetic groups: the colluvial (slide and creep deposits), talus, and solifluction and mudflow-type deposits are a single gravitational group, with deluvium included in the aqueous group.

Undoubtedly, such genetic classifications are of considerable theoretical interest, as they graphically illustrate the gamut of the processes which shape the slopes and are responsible for their deposits. However, for practical purposes, a general term is needed, applicable to the entire complex of the slope deposits which are formed by denudation processes for this complex only too often cannot be differentiated. Deluvium is the term most appropriate for this purpose, as it already is being used in this sense by most geologists. Limiting the term to the more strict meaning assigned to it by its author [6, p. 22] would restrict the use of this well-known term.

I want to emphasize that destruction, denudation, and deluvium are, in the working vocabularies of the geologists and geomorphologists most often used in the meaning I want to attribute to them:

destruction - breaking-up of rocks and a lowering of the earth's surface as a result of various exogenous processes;

denudation - the total effect of the processes active along interriver slopes: landslides and creep, sheet erosion, and solifluction, causing a redistribution of loose material along the slopes;

deluvium - loose deposits formed as a result of the denudation processes.

The common usage of these terms has been promoted to a considerable extent by their being used, in that sense, in the well-known work by Yu. A. Bilibin [1], which is still very popular with the geologists and geomorphologists who work on the exploration and development of placer deposits.

Special attention should be given to the word, erosion. Even its definition, as given by Nikolayev, is not quite specific.

Along any stretch of any river, there is a continuous process of washing out of alluvial deposits which compose river bottoms and banks. Just as continuous is the process of deposition of the river load. During any period of time, these processes are either mutually compensating or dominating. The washing-out may not be regarded as a destruction process, nor the piling-up as an accumulation process, because they are the two inalienable components of both the destruction process (the cutting-in, wherein the washing-out is in ascendancy) and the accumulation process (the piling-up of the alluvium, wherein the reverse is true). This mutual compensation of the washing-out and piling-up is a property of the dynamic equilibrium wherein the level of the earth's surface, subject to river action, is neither raised nor depressed, with the river only reshuffling the material supplied by the denudation processes.

It follows that washing-out and cutting-in are not to be confused. Nikolayev's definition of erosion as "an action upon the stream bed (mechanical action of water) as well as the

processes of corrosion, chemical suffusion, or chemical solution with a transfer of the mechanically captured or chemically dissolved mineral material" [5, p. 107] is applicable both to washing-out and to cutting-in; thus, applying the same term to essentially different phenomena.

As a matter of fact, erosion is used in this very sense. Some authors call washing-out processes erosion; for instance, S. N. Kalesnik believes that "cutting-in by a river, and depth erosion, are not equivalent terms; in depth erosion, cutting-in may be absent in the presence of processes nullifying the result of depth erosion" [2, p. 171]. The same idea is voiced by M. V. Piotrovsky: "The amount of cutting-in is the algebraic sum of the erosion and accumulation... It follows that a strict distinction should be made between erosion and cutting-in. Their usage as synonyms leads to confusion" [7, pp. 122-123]. [1]

Some other authors are very definite in calling cutting-in erosion. Thus, according to I. S. Shchukin, depth erosion is "a vertical cutting of rock by the stream" [9, p. 95]; while Yu. A. Bilibin speaks of the "depth-erosion phase or valley-deepening phase" [1, p. 147].

Finally, there are still others, utterly incomprehensible. For instance, K. K. Markov states that "depth, lateral erosion, and accumulation are not consecutive in time (as is often stated in our textbooks), but occur simultaneously" [3, p. 183]. If this quotation deals with the relief-making processes, how is it possible that a locality could be raised and lowered at the same time? If, on the other hand, the processes of washing-out and deposition are meant, a wash-out cannot be divided into depth and lateral. There does not seem to be any room for quarrel with the textbooks. It is also incomprehensible what erosion means to Karpov when he states that "the river keeps eroding until a limiting profile is attained" [3, p. 186].

It would seem that this confusion is enough to show that erosion has lost all its scientific and practical meaning. Would it not be better to abandon this term altogether, instead of reading into it some concrete meaning? Don't we have in our scientific literature such terms as cutting-in (vrezanie) and washing-out (razmyv), the very meaning of which would make them sufficiently specific? Instead of lateral erosion, we could speak of valley widening or river abrasion [8]; relief-making activity of rivers, instead of erosional activity; and fluvial relief [10] instead of erosional relief. As to the very indefinite term, base level of erosion, it is easy to see that it is altogether too superfluous for a correct interpretation of the essence of river processes. The fact is that all changes in the character of river activity, usually connected with the rise or fall of the base level of erosion (both absolute and relative), originate because of a change in the river gradient only, and not because of its elevation above the base level. Would it not be better to speak of the gradient changes, rather than of rises in the base level of erosion?

The term erosion probably will find its champions. Such champions are not lacking even with such moribund terms as orogenesis and epeirogenesis, as they were not lacking for such a term as diluvium, in its time; although its present usage has but ironic connotations.

In conclusion, I once more join Nikolayev [5] in his suggestion of a prompt review and unification of the geologic-geographic nomenclature. The shortcomings of the present one have become a serious hindrance to the development of science.

[1] Both quotations are not distinguished by precision of their terminology. In the first, washing-out is called depth erosion, although, not being directly expressed in the relief, it can have neither vertical (depth) nor horizontal (lateral) direction. In the second one, the deposition process, also non-relief forming, is called accumulation contrary to accepted usage of the latter term.

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A TIMELY AND USEFUL BOOK

by G. I. Blom

The Permian and Triassic deposits which occupy vast areas to the east and north of the Russian platform in the Ural area and in regions of Siberia and Kazakhstan, are characterized by an extremely diverse and complex structure, lacking marker horizons almost entirely. Their study is therefore difficult and results in numerous local stratigraphic schemes whose correlation challenges even experienced students. A comparative scarcity of organic remains and lack of information about them increases the difficulty of the task. It is only natural, then, that any new work on terrestrial organisms of the Permian and Triassic is of great interest to geologists who are students of the continental deposits of that age.

Well-substantiated correlation schemes for the continental Triassic and Permian deposits should be worked out in order to make state geological maps of various scales and to utilize the extensive field work already completed. Here, a study of vertebrate fossils should be of prime importance.

Field geologists, who study the distribution of the multicolored continental deposits, are most interested in biostratigraphically-oriented summaries which assist in stratigraphic studies of individual species and genera of terrestrial vertebrates, as well as of other fossil animals.

One of these summaries is reviewed here [1]. It is a resumé of most data on the localities containing Triassic vertebrates throughout the U. S. S. R. prior to 1953 (and partially to 1954 and 1955). This work gives an idea of the age of beds containing individual species or faunal groups. It also clarifies the stratigraphy of continental deposits by the use of terrestrial vertebrates. Its value in geologic studies is considerable.

The description of individual fossil sites is preceded by a stratigraphic sketch and a list of amphibians and reptiles for different divisions of the Permian and Triassic. There is a brief description of the five Permian faunal groups and two assemblages of Triassic terrestrial vertebrates, accompanied by locations of the respective faunal sites. Presenting such a chapter before describing the sites facilitates the use of the catalogue and makes it possible to correlate the individual vertebrate findings with their faunal and stratigraphic groups.

At the end of the chapter is a scheme of the stratigraphic distribution of faunal groups of terrestrial vertebrates and correlation with the accepted subdivisions. The scheme does not give the conventional subdivisions, but is original with the authors, although not sufficiently substantiated, particularly as to the relationship of the Isheyev deinocephalian complex and the Kazan stage. The scheme is at variance with the description of individual faunal sites, where the type localities for this complex, as well as the Isheyev (Kamennyi Ovrag), Cheremushka, Malaya Kinel', and others, are referred to - and quite rightly, according to the geologists familiar with them - as the Tatar stage. It would be well, in a following edition, to include the conventional subdivisions along with the author's own, in the descriptions of individual sites.

The main body of the catalogue, dealing with the description of individual fossil sites of terrestrial vertebrates on the age principal is well done. It describes 175 sites, of which only 16 percent have been studied to any extent; only 8 sites, or 5 percent, have been subject to extensive excavation and subsequent study.

These figures strongly suggest that, if the paleontology of terrestrial vertebrates of the U. S. S. R. has made such strides with such a low percentage of investigated fossil sites, greater development of geologic studies, as contemplated for the new Five Year Plan and accompanied, as they usually are, by collecting of terrestrial vertebrate fossils, will serve as a reliable base for stratigraphic differentiation of the Permian and Triassic continental deposits.

The description of each individual fossil site is preceded in the catalogue by a fairly detailed (geographic) description. However, the political geography is given according to the old usage rather than the new. Thus, the Sludka Bol'shaya site is located in Vetluga county, Gorky province, while it now is in Rojdesvenskiy county, Kostroma province; the Yusa site is located in Vologda province instead of Kostroma province. In reissuing the catalogue, the sites' coordinates should be corrected; this would facilitate their search on the map.

Of those known, the catalogue does not include the sites of village Velikoretskoye, on the Velikaya river, Medyanskiy county, Kirov pro-

vince, and of village Tikhonovskoye on the Vokhma river, Vokhma county, Kostroma province - both listed in the paper by A. I. Zoricheva [2] (a bibliographic rarity, for nearly the entire issue was burned in 1941).

The manual for the search for vertebrate remains in continental formations, written by I. A. Yefremov as an appendix to the catalogue, is its fitting complement and a great help in field work. A catalogue of fossil sites of the Permian and Triassic terrestrial vertebrates, as composed by expert paleontologists, is a good addition to the library of a field geologist engaged in the exploration of multicolored continental deposits. The errors noted can be easily eliminated in the following edition, the present one being small (1,200 copies). Such a re-issue, in the near future, is very desirable.

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CHRONICLE

CONFERENCE ON THE DIVISION OF CENTRAL ASIA INTO TECTONIC ZONES

A conference on the division of central sia into tectonic zones was held in Tashkent rom May 14 to 18, 1957. The conference was onducted by the Geologic Institute of the Uzbek cademy of Sciences. Its main task was to tudy various prevalent views on tectonic zonaon in central Asia in order to devise a aystem f division which could serve as a reliable base or metallogenic and other reference maps.

Members of many geologic institutes of entral Asiatic republics attended the confernce; represented were the Uzbek, Tadzhiktan, Kirgiz, and Kazakhstan academies of ciences; the Sredazneft and Turkmenneft soieties, the Sredazneftegazrazvedka, Sredazeftegeofizika, and Sredaztsvetmetrazvedka ombines; the geologic administrations of the epublics; as well as numerous institutions of igher learning: the Central-Asiatic State Uniersity, the Central-Asiatic Polytechnic Instiute, the Kazakhstan Mining and Mineralogical nstitute, and others. Also attending were epresentatives of some institutions from outide central Asia. Among these were the nstitute of Earth Physics of the Academy of ciences, U. S. S. R., the Experimental-Scienific Institute of Applied Geophysics, Ministry f the Petroleum Industry of the U. S. S. R., and he Moscow and L'vov Universities.

The conference was important for two reaons. First, it ended the long-lived isolation f geologic investigations in the separate repubics and countless institutions of central Asia. t this conference, for the first time in many ears, geologists met and exchanged news, oth geologists of the most diverse occupaions, studying the plains and the mountainous egions of central Asia, and geophysicists and etroleum geologists, investigating the zones f depression.

Though the conference did not arrive at any efinite or mutually acceptable scheme for the ectonic zonation of central Asia, it nevertheless opened the way for the creation of such a scheme in the near future. The conference elected a commission from among the representatives of the geologic organizations, mainly from the academies of sciences of the central Asian republics, to coordinate tectonic studies in central Asia.

After the conference, a 6-day excursion was conducted along route Tashkent-Ursatyevskaya-Kokand-Shorsu-Isfara-Vorukh-Shurab-Kokand-Fergana-Shakhimardan-Fergana-Namangan-Alabuga-Terek-Sumsar-Chust-Pap-Samgar-Pskent-Tashkent. Over 40 people took part in in the excursion. The members of the excursion visited the central part of the Fergana valley, and had an opportunity to become familiar with the folded structure of its borders near the northern parts of the Turkistan and Alay slopes, and the southern slopes of the Chatkalsk and Kurminsk ridges. The main guide of the excursion was the elder scientist O. A. Ryzhkov, a member of the Geologic Institute of the Academy of Sciences, Uzbek S. S. R. He was aided in the tour of the southern Fergana by Prof. D. P. Rezvoy.

One of the chief reports presented at the conference was by Prof. V. I. Popov (Academy of Sciences, Uzbek S. S. R.) on the nuclear theory of crustal development, and the application of this theory to the regional classification of central Asia. Popov claims that the geosynclinal theory is actually obsolete, and that the concept presently contained in the term "geosyncline" can hardly satisfy its original meaning. Popov contrasted the geosynclinal and nuclear theories. The basis of the latter consists in the subdivision of the earth's crust into two parts: 1) the nucleus, which as a consequence of depth differentiation, becomes saturated with granitic intrusions; and 2) the subnuclear, which is almost completely devoid of intrusions. The active nuclear phases are centers for the growth of the crust; their area is progressively being increased at the expense of subnuclear phases.

Popov, in classifying the mountainous part of central Asia, would consider the Fergana

depression, the Kuraminsky range, the Tadzhik depression, part of the Gissarsky range, and the crystalline zone of the southern Pamir as nuclear regions. The author mentioned Kara-kum (Chuy depression, Turansky plain) as a nuclear center, as well as a few other regions.

Yu. N. Godin, elder scientist and member of the Scientific-Experimental Institute of Applied Geology (NIIPG), presented two lengthy reports of a general nature. In the first, he graphically demonstrated the great potential of geophysical methods in the study of regional tectonic structures. In the second, on the basis of these methods, he drew a general picture of the geologic structure of central Asia, focusing on major depressions. Godin described the Kubadag and the Bol'shoy Balkhan as a transitional zone between the bordering Alpine folded region and the epi-Hercynian platform. He distinguished between intermediate massives, typically rounded or oval in outline, which characterize the Alpine and the epi-Hercynian platforms, and the mobile zones between them. The first are characterized by large positive gravity anomalies; the second, by negative or weakly positive gravity anomalies and linear magnetic anomalies. Godin also described the intermediate massives in the region of the Ust'Urt, Kara-Bogaz-Gol, Kara-Kum, and the southern Caspian depression.

Data on the structure of the Fergana depression obtained from geophysical studies were given in the papers by B. B. Tal'-Virskiy and B. S. Vol'vorskiy (Sredazneftegeofizika). The Paleozoic basement is gradually subsiding along fractures towards the central part of the depression from the direction of its mountain margins. The fractures are roughly parallel to the marginal structures in the middle of the depression. The surface of the basement at a depth of 10 or 12 km is practically horizontal.

The geologic formation and structures of the Fergana depression were described in a detailed paper by O. A. Ryzhkov (Academy of Sciences, Uzbek S. S. R.). He described the growth of the depression in the middle Cenozoic. It was shown that hollows parallel to the Turkestan-Alay and Fergana uplifts were "embryonic" depressions. The lecturer distinguished a series of anticlinoria and synclinoria within the present structure of the depression. The folds were formed over a long period of time and are composite in nature; Ryzhkov ascribes their formation to lateral pressures from adjoining uplifts. In analyzing the history of the Fergana depression and its separate folds, the author applied a set of new procedures to tectonic research.

Prof. D. P. Rezvoy gave a long paper on the geologic structure and tectonics of the southern margin of Fergana (Alay-Turkestan mountains region), supported by illustrations from maps having a scale of 1:200, 000. His work is bas on many years of study in this district. He divides the territory in question into a series zones. These zones have been subject to diff ential geologic-tectonic activity since the Cam brian. Many are, in the opinion of the author divided by deep-seated fractures which have been active over a long period of time. It should be specifically mentioned here that the southern Fergana foothills were tectonically classified by Rezvoy without geophysical data (unavailable during mapping). Yet, his classi fication is generally compatible with current ideas based on geophysical data.

L. G. Thukovskiy, chief geologist of Sreda nefterazvedka, summarized the results of oil exploration in the Bukharo-Khivin depression. The middle Cenozoic strata in this depression thickens progressively from the Hercynian ma sif at Kyzylkum in the northeast to Amu-Dary in the southwest and, even to a greater degree toward the Gissarsky foothills where the autho noted evidence of Alpine depression. Geophys cal and drill-log data indicate the existence of two uplifts in middle Cenozoic strata, which are probably inherited from Hercynian structures. One strikes along the Amu-Darya; the other, at some distance to the northeast, has a parallel strike. Both uplifts consist of local structures of a typical platform structure, which have yielded commercial oil and gas pro duction. Toward the Gissarsky, the orientation of the structures changes and parallels this range. Their morphology also changes.

A suitable addition to the papers on the structure of the oil-bearing depressions of central Asia was given by F. T. Kashirin, corresponding member of the Academy of Science of Kirgiz S. S. R., on the regional classificatio of Jurassic coal-bearing depressions of north-Tien'-Shan. He reported that a platform existed at one time south of the Caledonian geo syncline which encompassed the Fergana lowland and bordered the mountain ranges to the north. The platform was somewhat altered by subsequent movements.

S. A. Zakharov and M. M. Kukhtikov, senior members of the Geological Institute of the Academy of Sciences, Tadzhik S. S. R., gave paper devoted to problems of methodology in regiona tectonic classification, using the territory of Tadzhikstan as an example. Zakharov, studying the Tadzhik depression, proposed that during the Mesozoic, latitudinal depressions (i. e. depressions parallel to the Gissar range) predominated. Reconstruction of the tectonic pla and the appearance of a submeridianal structu took place only in the Tertiary. Kukhtikov illustrated his opinions on the principles of regional tectonic classification by examples from the Gissar-Zeravshan mountain system, withi which he distinguished a considerable number of zones which had developed in entirely differ

nt ways.

E.K. Karpovaya (VSEGEI) also read a paper the conference on the development of magmatic activity in central Tien'-Shan'. Prof. V.E. Khain (MGU) gave a paper on some problems involved in the methods of regional tectonic classification. In addition to those listed in the program, Prof. V. I. Slavin (MGU) gave a report on the structure and development of intermediate massifs, citing the Pannon (Hungarian) massif as an example. This paper aroused the interest of the geologists from Central Asia because several tectonists regard the Fergana depression as an intermediate massif.

Popov's paper occasioned the most lively exchange of opinions in the discussion. While recognizing the considerable interest in his opinions, and the validity of individual cases noted in his nuclear theory, S. A. Zakharov, B. A. Petrushevskiy, V. E. Poyarkov, D. P. Resvoy, V. E. Khain, among others, made some critical comments. Zakharov was in agreement with Popov's criticism of the geosynclinal theory, but observed that the nuclear theory contained more, rather than fewer, inadequacies. V. E. Khain pointed out that the geosynclinal theory was and remains a reliable basis for regional tectonic classification, since even a century of evolution has not managed to restrict the meaning of the term. Popov set his nuclear theory against the geosynclinal theory to no purpose: the question is that of developing and completing this theory - not of rejecting it. Petrushevskiy noted that Popov's approach to regional tectonic classification impoverished its scope, actually using the development of granitic masses as the main criterion. In addition, some concrete observations were made, in relation to Popov's tectonic scheme, concerning the 'Nuclear' nature of the Tadshik depression, together with some other problems.

In his reply, Popov repeated his arguments against the geosynclinal theory and observed that Godin's ideas on the intermediate massif, and on the mobile zones dividing them, as well as Slavin's treatment of the intermediate massif, were similar to his own opinions.

A paper by O. A. Ryshkov also occasioned some critical comments. Petrushevsky noted the value of the paper, but at the same time pointed out that Ryshkov had no grounds for confining the anticlinoria and synclinoria to the Fergana depression, and that he underestimates the role of the movement of the Paleozoic basement. Furthermore, Petrushevsky noted, there is no basis for Ryzhkov's idea that lateral pressure is the main cause of folding in this region.

High praise was given to the tectonic scheme of Yu. N. Godin, but for the observation that there was no connection between the classification of the zones of depression and of the mountain regions of Central Asia.

The exchange of opinions on the tectonics of Central Asia, and in particular of Fergana, continued during the excursion. The participants in the excursion came to the unanimous conclusion that it was impossible to understand the structure of the middle Cenozoic series of the Fergana depression without taking into consideration the tectonics of its Paleozoic framework. Unfortunately, oil geologists have not paid the necessary attention to the Paleozoic formations in their investigations. The Paleozoic basement of the depression is not only broken into blocks, but parts of it are also folded into some of the anticlines. Attention was drawn to a definite difference in structure between the northern and southern margins of the Fergana depression. This is no doubt due to the more or less early consolidation of the Paleozoic basement to the north on the one hand, and to the much later development of the Cenozoic subsidence, on the other.

The anticlinal zones of Fergana cannot be called either anticlinoria or uplifts, in the strict sense of these terms. Proposals have been made for a specific terminology to be applied to similar formations in other analogous depressions of Central Asia.

In conclusion we should like once more to emphasize that the Tashkent conference and the accompanying excursion was a very useful affair which undoubtedly promoted a more effective development of tectonic research in central Asia. The organisers of the conference, G. A. Mavlyanov, corresponding member and director of the Geological Institute of the Academy of Sciences, Uzbek S. S. R., N. V. Petrov, the deputy director of the Geological Institute, Professors V. I. Popov, O. A. Ryzhkov, I. P. Sokolov, chief geolgists of Sredaznefta (Central Asian Oil) and their assistants ensured the successful running of the Conference and excursion, as well as the efficient organization of all affairs with which they were associated.

B. A. Petrushevsky V. E. Khain

CONFERENCE ON THE STUDY AND UTILIZATION OF CLAYS

The first conference on the study and utilization of clays held in the U. S. S. R. took place in L'vov from May 26 to June 1, 1957. It was organized by the I. Franko State University of L'vov, six institutes of the Academies of Science of the U. S. S. R. and the Ukrainian S. S. R., and other scientific organizations.

More than 100 reports and communications were presented by almost 60 scientific and industrial organizations. About 250 contributors took part.

The following subjects were discussed: 1) general problems of clay mineralogy (25 papers); 2) methods of mineral investigation and physico-chemical properties of clays (10); 3) engineering-geologic properties of clays and minerals (12); 4) studies of clays and soils of various regions (14); 5) clay technology (23); and 6) results of studies on bentonites, bauxites, loess, and weathering crusts (19 papers). Since the material had been printed beforehand, the papers did not take much time; their discussion was thoroughly satisfactory.

The following questions were discussed in detail: mineralogic nomenclature (beidellite and monothermite), thermal and dehydration curves, the nature of thermal effects, the significance of dispersion in thermal and X-ray analysis, the importance of the quantitative determination of the separate clay minerals and their mixtures, cases of formation of hydromica from montmorillonite and of collomorphic kaolin and beidellite products from lamellar kaolin, the achievements and potentialities of electron microscopy, the character of isomorphism and epitaxial growths among clay minerals, the determination of particle size by low-angle methods, the study of deformation in clays by X-rays, and others.

A series of papers was devoted to the bentonites of the Caucasus, the western parts of the Ukrainian S. S. R. and Zakarpatya (Trans-Carpathia) Cherkass, Turkmenistan, and other regions.

Reports were made on the oil-producing clay formations of the Caucasus and eastern Carpathians.

Reports were given of studies on Carboniferous argillites, clays, and refractory clays of the L'vov-Volyn basin; the Permian and Triascic sediments of the Ukrainian S. S. R.; on the Meso-Cenozoic section of central Kazakhstan; on the Jurassic coal-bearing series of Dagestan; on the Balakhon series of the Kuznets section; on the upper Permian clays of the Upper Pechora; on the Latnin deposit; and others.

Among the papers on bauxite, the most interesting were those on the formation of boehmite from chlorite schists of the Kursk magnetic anomaly, on the presence of clays with an alumina content of 39.5 to 55 percent among newly deposited secondary kaolins (Ukrainian S. S. R.), and on the weathering products of clay from the Paleozoic bauxitic rocks of central Kazakhstan.

A chemical and mineralogic study of the apple-green clays from the Nikopol deposit resulted in the isolation of hydroglauconite, which is further altered to ferrichlorite and hydromica.

In the papers on weathering products, attention was drawn to the necessity of determining the oxide content per unit volume when computing the composition of a given crust with respect to certain elements contained in it. Secondly, during the investigation of clay, it was advised that attention be given to the solution state of silica extracted from weathering products.

Great interest was occasioned by papers on the composition of solutions extracted from clays under pressure.

At the Conference, for the first time an engineering geological slant was given to the study of clays. The following topics were discussed: problems of structure formation, diffusion and diffusion leaching, petrographic features of clay soils, genesis and conditions of formation of these soils in relation to their engineering-geologic features, the use of clays in mine construction and also plastification of structural solutions, the selection of drilling muds, and other problems.

A series of papers were devoted to the technological properties of clays: they dealt with questions on the relation between these properties, the mineralogic composition and genesis of clays, the investigation of their catalytic properties, the use of some forms of clay for light-weight fillers and similar structural materials. The papers were also concerned with improved processing methods, which would result in white, high-strength, low-firing cements, thin ceramic ware, compact refractory fireclay, ceramrite (a porous dry filler), green glassware, and other products.

Attention was focused on the inadequate development of investigations of problems of genesis, classification, structure, synthesis, and laws of clay and clay-mineral distribution. Also noted was the lack of understanding by some of the scientific and industrial institutions of the importance of clay and clay minerals, which limits the depth and breadth of investigations, as well as the lack of agreement among these institutions regarding the results of joint investigations. The insufficient investigation of mineral contents in many deposits and soils, and of the physico-chemical and engineering-geologic properties of clays were noted.

A number of decisions and recommendations were adopted for the study of clay geology, its engineering and geologic properties, the study of mineral resources, the develop-

ment of structural-physical and physico-chemical methods of studying the crystalline structure and properties of clay and clay minerals. An All-Union committee on clays was selected from the representatives of the Soviet Republics and the major regions and institutes. A departmental committee consisting of F. V. Chukhrov, E. K. Lazarenko, I. I. Ginzburg, V. P. Petrov, M. F. Bikulovaya was also chosen. It was proposed that the results of investigations and utilization of clays should be published in an interdepartmental journal, to be organized at L'vov University. The publication of the conference proceedings are also projected, and abstracts of papers on the present conference on the study and use of clays (180 pp.), and the resolutions of the conference (18 pp.), have already been published by the L'vov University Press.

I. I. Ginzburg

THE SECOND SESSION
OF THE INTERNATIONAL ASSOCIATION
FOR THE STUDY OF THE INTERIOR
OF THE EARTH'S CRUST, SCOTLAND

The Second Session of the International Association for the Study of the Interior of the Earth's Crust began on September 12, 1957, in Edinburgh. Participants from the Academy of Sciences of the U. S. S. R. included: L. V. Pustovalov, Corresponding Member; R. A. Borukayer, Academician, Kazakhstan S. S. R.; E. V. Pavlovskiy, Doctor of Geological and Mineralogical Sciences (Geological Institute of the Academy of Sciences of the U. S. S. R.); and N. V. Khabarin, Secretary.

Relations between the Soviet delegation and Professor P. Michot (Belgium), the general secretary of the association; Professor J. Anderson (Cardiff) who directed the geologic excursions of the session; and his assistant, Dr. J. Sutton (London) were most cordial.

The Belgian delegation nominated P. A. Borrukayer, spokesman of the Soviet delegation as chairman for the duration of the session; he was elected unanimously.

The association was created at the XIX session of the International Geological Congress in Algiers, and now consists of over 60 members (members are individuals rather than establishments or organizations). A constitution has not yet been established.

The second session was attended by only 25 people representing 8 countries: Belgium, Great Britain, France (including Algiers), Holland, West Germany, Norway, Switzerland, and the U. S. S. R. A group of about 10 young English students, including research students, participated; they were not members of the association.

Excursions through Scotland formed part of the program. The participants examined Scottish formations and exchanged opinions on the problems involved and on the results of future investigation. A long excursion to the Scottish Highlands was planned so that Dalredian and Moinian metamorphic series, which occupy the greater part of the Highlands, could be investigated. The great Moine thrust on the northwestern boundary of Caledonian folding and the relation between the folded zone and the platform were demonstrated with particular thoroughness. In this area, the type Archean (the Lewision) and Proterozoic (Torridonian and Moinian) of Scotland and the extraordinarily complex tectonics of the boundary of Caledonian folding were observed, as were the many small stocklike intrusions and dikes resulting from post-Caledonian magmatic activity.

The Soviet geologists were greatly interested in personally observing the ancient Scottish geologic formations. These are the classic formations described in all geologic textbooks and manuals. The type section of Caledonian folding (Caledonia Scotland) is located in Scotland.

It was obvious that the ancient formations had been studied in great detail by English geologists. However, some basic problems concerning stratigraphy, facies relationships, and history of the metamorphic zones have not yet been adequately studied. Methods of paleontologic and petrographic investigations have not been adequately applied to the oldest geological formations of Scotland. This lack is reflected in the quality of the geologic map of Scotland, on which vast spaces are shown as regions of a thick, undifferentiated series of one geologic age. The geologic map of Scotland, on a scale of 1:625,000, requires much more detailing. This feature of the study of Scottish geology was frankly commented upon by Soviet representatives at the final meeting of the session.

During the excursion, evening meetings dealt with organizational questions, particularly with drafting a constitution for the association. The Soviet delegation was active in this discussion and suggested improvements for the original text. At one meeting, a new tectonic map of the U. S. S. R., on a scale of 1:5,000,000 edited by Academician N. S. Shatskiy and published in Moscow in 1957, was discussed.

It was decided that the next (third) session of the association would be held in 1959 in France (Central Massif).

Geologists with the Soviet delegation were admitted to membership.

During their stay in London, the Soviet delegation visited the Geological Society of London, and discussed its activities with Professor L. Hawkes, president of the society; his deputy A. Butler; the secretary of the society; and other members.

The delegation presented a copy of the tectonic map of the U. S. S. R. and explanatory notes to the Geological Society of London from the Geological Institute of the Academy of Sciences of the U. S. S. R.

The delegation returned to Moscow on September 29, 1957, after 18 days in England.

L. V. Pustovalov R. A. Borukayer
E. V. Parlovskiy

CONFERENCE ON THE UNIFICATION OF STRATIGRAPHIC SCHEMES OF THE NORTHEAST U. S. S. R.

An interdepartmental conference took place in the town of Magadan, from May 10 to 21, 1957, with the aim of coordinating stratigraphic schemes of the northeast U. S. S. R. During the past 15 to 20 years, the geologic structure of the vast territory of Dal'stroy has been well studied. The vast unstudied spaces between the Lena river on the west and the Chukot peninsula on the east were recently referred to as "white blots" on the geologic map. These "blots" have been filled in on the geologic map of the U. S. S. R. published in 1956 (1:2, 500, 000).

The special geologic structure of the region situated within the belt of Pacific folding, the broad knowledge of its stratigraphy, and the fact that no extensive conference had taken place before aroused extraordinary interest in the Magadan meeting. According to N. P. Anikeyev, president of the organizational committee of the Conference, 239 people, representing 21 organizations, took part. Besides geologists from Dal'stroy, the Conference was attended by representatives of the geologic institutes of the Academy of Sciences of the U. S. S. R., the ministerial organizations of geology and mineral resources, the oil industry and others, universities and institutes specializing in geologic subjects, and also Yakut, Khabarov, Primor, and other geologic organizations. Approximately 104 papers were read and about 80 contributions were made to the discussions.

Papers containing plans for the unification and operation of the stratigraphic scheme for northeastern Soviet Union were heard in plenary sessions. The stratigraphy of the Precambrian and of the Lower and Middle Paleozoic were dealt with in a paper by A. A. Nikolayev; the Permian by A. V. Zimkin; the Triassic by Yu. N. Popov; the Upper Triassic and Jurassic by I. I. Tuchkov; the Lower Cretaceous by G. G. Popov; the Upper Cretaceous by A. F. Yefimov and V. A. Titov; the Tertiary by A. G. Pogozhev and A. I. Semeykin, and the paleontological basis of the stratigraphy of Quaternary deposits by A. P. Vaskovskiy.

The following papers were also heard in plenary sessions: L. A. Snyatkov on the geologic structure of northeastern U. S. S. R., V. V. Menner on the principles of compiling a unifying scale and also on the principles of comparison between suites of different facies (marine and continental), and Yu. M. Pushcharovskiy on the basic trends in research at the Geological Institute of the Academy of Sciences of the U. S. S. R., which deal with the belt of Mesozoic folding in northeastern Soviet Asia.

Additional papers, as well as discussions on essentially stratigraphic problems and the final development of various stratigraphic schemes took place in the sectional meetings. There were four working schemes: a) Precambrian, Lower and Middle Paleozoic; b) Permian, Triassic, and Jurassic; c) Cretaceous; and d) Cenozoic.

The main result of the conference was the development of practical stratigraphical schemes and correlation tables for separate geologic systems. The unification scheme can be developed to a very limited extent at present, for geologic knowledge and biostratigraphic foundations are still inadequate. However, unification schemes have been worked out for the Permian and Triassic systems.

The first Precambrian formations formed were those within the Prikolym uplift, the Okhat and Omolon massifs, and other regions. Cambrian deposits in the Tas-Khayakhtakh range, which had been distinguished by using paleontologic data (Cm3), are now apparent within the Okhot massif, where they are represented predominantly by limestones and marls of the platform type. The subdivision of the Ordovician into stages holds only for the Novosibirian islands. The younger Paleozoic deposits, Silurian, Devonian, and lower Carboniferous have been better studied. This applies especially to the Kolymo-Indigir region (the basin of the river Omulevka) which, for the future, can be regarded as the basis for corresponding stratigraphic schemes for other regions of the northeast U. S. S. R. The need for a special study of the boundary between the Silurian and Devonian was discussed. The wide development in the Koryak range of Middle and Upper Paleozoic deposits (D_1-P_2) which had previously been considered to be partly Cretaceous evoked great interest. The Upper Paleozoic complex forms a thick series of siliceous rocks, basic extrusives, and limestones (in lenses) containing Paraschwagerina

(paper by Rusakov). Upper Permian "columns" which had previously been thought to be Inoceramus prisms were also found.

The possibility of applying the stratigraphic scheme which had been developed for the Russian platform and the Urals to the stratigraphy of the Permian deposits of northeast U. S. S. R. was thoroughly discussed. A local tripartite scheme of unification, roughly comparable with the subdivisions of the eastern European scale was developed. It was noted that the Permian section of the northeastern U. S. S. R. is unique, because it consists of marine formations (L. A. Snyatkov).

On the suggestion of Yu. N. Popov, a differentiation of Lower Triassic formations into two series was adopted: the Indian and the Olenekian. It was noted that paleontologic data were most important. The upper boundary of the Triassic should be defined more exactly and, in particular, more work done on the problem of Rhaetian deposits.

Enough is known about Jurassic deposits to develop a stratigraphic and biostratigraphic scheme and to correlate the sections. Permian, Triassic, and Jurassic deposits from bulk of the Mesozoic folded region of the northeastern U. S. S. R.

Considerable advances have been made recently in the study of marine Cretaceous deposits in the Anadyr-Penzhin region. Little has been done, however, in the study of Cretaceous formations of continental origin, which form large structures in the central regions of northeast U. S. S. R., or in the study of the volcanic series widely developed in Okhotsk.

The Tertiary has been best studied in the Anadyr-Penzhin, eastern Koryak, and Alyntor regions, and, to a lesser extent, in the Okhotsk zone - especially well in northeast U. S. S. R. It was noted that the boundaries between Cretaceous and Tertiary and the upper limits of the Neogene should be defined more precisely. It is necessary to use all methods of comparison when examining suites of different facies, because the Cretaceous and Tertiary contain marine, continental, and volcanic formations.

Finally, the conference announced that substantial results had been achieved in the study of the Quaternary of the northeast U. S. S. R. This is particularly reflected in the establishment of flora and spore and pollen complexes for the greater number of the series in the Quaternary system. The necessity of a thorough study of the Quaternary deposits which form lowlands and tectonic depressions, was discussed, as were the need for investigation of glacial deposits, in order to determine degree of glacial activity, the multilateral study of alluvial deposits, features of ancient relief, and so forth.

It was thus obvious that deposits of all systems should be subjected to systematic study and the regions where this work should be accomplished were indicated. Special attention was given to the development of a biostratigraphical foundation for the differentiation of all geological formations. This would necessitate additional assemblages and extensive examination of paleontologic and paleophytologic collections. Determination of the absolute age of rocks is extremely important. Faunal complexes, which are very different from those in the European and Pacific provinces, were planned for the geologic systems. These have deep historical roots and thus should be taken into consideration in biostratigraphic investigations.

There is a strong demand by practicing geologists for the preparation of field paleontologic atlases for the systems of the Paleozoic and Mesozoic.

The conference elected a commission for general editing of the resolutions which had been adopted, and for the publication of its transactions which should be issued in 1958. The resolutions of the conference must be ratified by the All-Union Interdepartmental Stratigraphic Committee.

Yu. M. Pushcharovskiy

CONFERENCE ON THE GEOLOGIC-ENGINEERING PROPERTIES OF ROCKS AND METHODS OF STUDYING THEM

A conference devoted to the problem of the geologic-engineering study of rocks took place in Moscow, from April 15 to 20, 1957. The conference was convened by the Bureau of the Geologic-Geographic Department, Academy of Sciences of the U. S. S. R.; F. P. Savarensky Laboratory on Hydrogeological Problems, Academy of Sciences of the U. S. S. R.; together with the Moscow State University, the Moscow Geological Research Institute, and the All-Union Scientific Research Institute on Hydrogeology and Geologic Engineering.

Geologic-engineering studies of rocks began with the inception of the 5-year plans as a result of the demands made by the building industries on the investigation and description of rocks - particularly the clay rocks, which are indispensable to any construction. Lately, this field of research has become one of the leading preoccupations of geologic engineering, and a separate branch in the field of rock study.

The results of geologic-engineering studies

of sedimentary rocks give valuable supplementary material for the determination of the degree and state of lithogenesis. At the same time they help solve some problems in tectonics and stratigraphy and, what is most important, they permit a thorough study of the resistance and deformation of rocks in the natural conditions of their deposition. The last is particularly indispensable in relation to clay rocks, whose physico-mechanical properties are still poorly known. Often, their weak resistance results in the deformation of structures built upon them, necessitating the application of special reenforcement to secure them.

The basic theoretical problems are the study of resistance and deformation in rocks in their natural conditions of deposition, the study of the relation between geologic-engineering properties of rocks and their composition, structure, history of deformation, and contemporary conditions of formation. They also are the studies of the laws controlling the changes in the rock properties under the cumulative activity of natural factors and structures.

Translations and other problems were widely discussed at the plenary and sectional conferences. More than 2,000 specialists of various backgrounds took part in the conferences. Among them were geologists, petrographers, mineralogists, chemists, geologic engineers, hydrogeologists, planning engineers, construction engineers, and so forth. They represented 451 organizations, among them practically all the academies of science from the Soviet Republics, many branches of the Academy of Sciences of the U. S. S. R., the higher educational institutes, and branches of the scientific research institute, as well as many industrial organizations of the various ministries. Among the last the Gidroproyekt and the Gidroenergoproyekt of the Ministry of Electrification of the U. S. S. R. were the most active.

Bulgarian scientists (A. T. Demirov and others) also took an active part in the work of the conference, describing in detail the position of geologic engineering studies of rocks in their republic.

Advanced publication of the papers, more than one hundred in number, by the organizational committee made it possible to disperse with their reading, and devote all the time to evaluation and discussion. It was also possible for two plenary conferences to serve as information sessions on current investigations, with the aim of coordinating them.

After the introductory remarks by D. I. Shcherbakov, secretary of the Geologo-Geographical Department of the Academy of Sciences of the U. S. S. R., papers presented by V. A. Priklonskiy, chairman of the organizational committee and director of the Laboratory on Hydrogeological Problems of the Academy of Sciences of the U. S. S. R., were discussed. These papers were: Contemporary Achievements and Tasks of the Geologic-Engineering Studies of Rocks and Petrogenesis and Formulation of Geologic-Engineering Properties of Rocks. The other papers discussed were: Acad. P. A. Rebinder's Structural-Mechanical Properties of Argillaceous Rocks and Contemporary Concepts of Colloidal Physico-Chemistry, and corresponding member of the Academy of Sciences of the U. S. S. R., B. V. Deryagin's Studies on the Properties of Thin Layers of Water, in Connection with the Properties of Argillaceous Rocks, Prof. I. V. Popov's The Importance of the Crystalline Structure of Minerals from Argillaceous Rocks for the Development of their Properties, Prof. M. N. Goldstein's Creep and Sustained Strength in Clay Rocks, and many others.

The sections worked with three basic problems to discuss: 1) the study of the geologic-engineering properties of rocks (chairman, Prof. Ye. M. Sergeyev); 2) geologic-engineering description of the regional, genetic, and petrographic types of rocks in the U. S. S. R. (chairman, F. V. Kotlov, candidate for geological-mineralogical sciences); and 3) the methods of geologic-engineering studies of rocks (chairman, Prof. N. V. Kolomensky).

In all the sections, great attention was given to the strength of easily deformed rocks, particularly clay rocks, as well as to problems of geologic-engineering classification of rocks. A special commission of the organizational committee, lead by Ye. M. Sergayev, was formed to prepare the questions to be discussed.

Problems of scientific terminology in the field of geologic-engineering studies of rocks were discussed in reports by another commission, also formed by the organizational committee, and conducted by V. A. Priklonskiy.

In its resolution, the conference commended the timely initiative of the Hydrogeological Laboratory. They also mentioned the necessity of conducting similar conferences in the future, at least once every three years. The conference stressed the necessity of approaching the theoretical and practical problems by implementing the various methods and contemporary ideas of geology, mineralogy (colloidal in part), petrography (particularly of sedimentary rocks), physics, chemistry (colloidal in part), rheology and mechanics, and partly, the physico-chemical mechanics of finely dispersed systems. The importance of investigating the natural strength of rocks, and the dependence of geologic-engineering properties of rocks on petrogenesis, and their petrographic qualities, were particularly stressed.

Also noted was the necessity for further

improvement in the methods of geologic-engineering studies of rocks, particularly in field techniques and apparatus. In connection with this, the conference considered it indispensable to assign to the Hydrogeological Laboratory the problem of creating an organizational commission on geologic-engineering methods of studying rocks, and to establish it permanently.

The necessity of strengthening international ties in the field of geologic-engineering investigations of rocks, in particular with the International Society on Ground Mechanics (London), was also stressed.

The conference mentioned the unnatural position of the F. P. Savarensky Hydrogeological Laboratory, which is the only institute of its kind in the Academy of Sciences of the U. S. S. R. but whose reorganization has not yet been accomplished. It was agreed that the Hydrogeological Laboratory of the Academy of Sciences of the U. S. S. R. would be the coordinating and organizational center. Being the initiator of the conference, the institute has been recommended as the guiding organ in this work, particularly in the publication of informative bulletins, with notes on investigations carried on by the various institutions, and their results.

V. A. Priklonskiy

THE SIXTH SESSION OF THE COMMISSION TO DETERMINE THE ABSOLUTE AGE OF GEOLOGIC FORMATIONS OF THE DEPARTMENT OF GEOLOGIC AND GEOGRAPHIC SCIENCES OF THE ACADEMY OF SCIENCES OF THE U. S. S. R.

The commission met in conjunction with the Urals branch of the Academy during the VI session in Sverdlovsk from the 22nd to the 27th of May, 1957. The meeting considered problems of determination of the absolute age of the Urals, Zabaykal'ya, the Far East, the Ukraine, the Caucasus and central Asia. Techniques were also discussed. Approximately 43 papers were presented by a wide range of specialists: geologists, physicists, chemists, radiologists, and others from various establishments of the Academy of Sciences and departmental organizations.

More than 200 people attended the meetings. Approximately 90 of these were representatives of institutes of the Academy of Sciences (Radiation Institute GEOKHI, Geological Institute, and Laboratory of Precambrian Geology); of the Academy of Sciences of the Ukrainian S. S. R.; the Academy of Sciences of the Georgian S. S. R., the Azerb Adzhan S. S. R., and the Armenian S. S. R.; the Academy of Sciences of the Kazakhstan S. S. R.; the Dagestan, Urals, Bashkir, Western Siberian branches of the Academy of Sciences of the U. S. S. R.; MGU, LGU, and VSEGEI; the directors and also some of the branch geologic establishments.

The Sixth Session adopted a resolution to study, during the current five year plan, the further, more detailed differentiation of Precambrian formations of the Ukraine and to extend age-determination studies in the Urals and other territories, and also to find new radioactive methods of determining absolute age and perfect those already known.

The commission has accomplished important work by drawing a much wider circle of geologists into this field of interest and by popularizing these ideas and developing effective methods.

The following papers were read:

1. Introductory remarks, by D. I. Shcherbakov;

2. Determination of the absolute age of the igneous, metamorphic, and sedimentary rocks of the Urals, by L. N. Ovchinnikov, A. S. Shur, and M. B. Panova;

3. First results of the determination by the potassium-argon method of the absolute age of the rocks of the eastern edge of the Russian platform and southern Urals, by M. A. Garris;

4. Age of the Kochkar magmatic complex of the southern Urals by the lead-argon method, by L. V. Komlev, S. I. Danilevic, B. K. L'vov, G. H. Kuchina, A. D. Mikhalevskaya, and F. F. Fyodorova;

5. Some data on the composition and structure of the crystalline basement of the Russian platform and its relationship with the Ural and Baltic shields, by L. A. Vardanyants;

6. Determination of the age of the sedimentary formations of the oil-bearing province of the Dagestan A. S. S. R., by Kh. I. Amirkhanov and K. S. Magatayer;

7. Age of the granitoids of Zabaykal'ya by the argon method, by N. I. Polevaya and N. N. Chernova;

8. Geochronology of the Far East, by N. I. Polevaya;

9. On the application of the potassium-argon method to geology in the light of the results of investigation of the rocks and minerals of the Caucasus, by G. D. Afanas'ev;

10. Age data for the Caucasus, by Ye. V.

Studenikova, K. G. Knorre, S. I. Zykov, and V. A. Fyodorova;

11. Basic data on the geochronology of the Precambrian of the Ukraine, by N. P. Semenenko, M. N. Ivantishin, and Ye. S. Burkser;

12. Geologic and absolute age of the granitoids of the Ukraine, by Yu. I. Polovinkina, N. I. Polevaya, and G. A. Murina;

13. Age determinations of granitoids of the Ukraine, by A. P. Vinogradov, A. I. Tugarinov, S. I. Zykov, and V. A. Fyodorova;

14. Geochronology of the Precambrian of Africa, by N. P. Semenenko;

15. On the age of the geologic formations of the southwestern part of the Precambrian of the Ukraine (Podoliya), by L. V. Komlev, S. I. Danilevich, A. D. Mikhalevskaya, V. T. Savonenkov, and M. S. Filippov;

16. New age data on the Precambrian of the Ukraine, by L. V. Komlev, S. I. Danilevich, K. S. Ivanova, V. T. Savonenkov, and M. S. Filippov;

17. On the age of the rare-metal intrusion of Akchatau by the helium method for monazites, by L. V. Komlev, E. K. Gerling, and K. K. Zhirov;

18. Age of the rare-metal granite intrusion of Akchatau by the lead and argon methods, by L. V. Komlev, S. I. Danilevich, S. I. Zykov, K. S. Ivanova, G. N. Kuchina, A. D. Mikhalevskaya, and M. S. Filippov;

19. On the suitability of some radioactive minerals for determining the age of, for example, the Slyudyanka deposit, by V. V. Zhirova, S. I. Zykov, and A. I. Tugarinov;

20. Sublimation as a method of determining the isotopic composition of lead, by I. Ye. Starik, Ye. V. Sobotovich, G. V. Avzdeyko, G. I. Lovtsyus, and A. V. Lovtsyus;

21. The form of occurrence of lead in radioactive minerals, by I. Ye. Starik, Ye. V. Sobotovich, G. V. Avzdeyko, G. I. Lovtsyus, and A. V. Lovtsyus;

22. The determination of the isotopic composition of small amount of lead, by S. I. Zykov and N. I. Stupnikova;

23. Relative leaching of some isotopes, by I. Ye. Starik, F. Ye. Starik, and A. N. Yelizarova;

24. Kinetics of the leaching process, by I. Ye. Starik, F. Ye. Starik, and Ye. P. Petryayev;

25. On the role of adsorption processes in the study of the leachability of the isotopes of some elements from monazites, by I. Ye. Starik and K. F. Lazarev;

26. The problem of the disturbance of proportions of isotopes in natural formations, by I. Ye. Starik, F. Ye. Starik, and B. A. Mikhalov;

27. The problem of preservation of radiogenic argon in glauconites, by Ye. V. Bortnitskiy;

28. On a method of mass-spectrographic determination of radiogenic argon rocks, by S. B. Brandt;

29. Age determination of sedimentary rock by the argon method, by I. Ye. Starik, A. Ya. Krylov, N. V. Baranovskaya, and Yu. I. Silin;

30. An application of the scintillation method for age determination by radiocarbon, by I. Ye. Starik and Kh. V. Protopopov;

31. Effect of moisture on emanation, by V. I. Baranov and A. P. Novitskaya;

32. Problems of age determination of meteorites, by V. I. Baranov;

33. Investigation of the flow of neutrons in the Earth's crust, by L. I. Shmonina, V. V. Cherdyntsev, L. L. Koshkarova, and V. F. Ostanenko;

34. Chemical treatment of specimens in radiocarbon dating by the scintillation method, by I. Ye. Starik, S. V. Butomo, V. M. Drozhzhin, and Kh. V. Protopopov;

35. Prospects for the application of the determination of the absolute age in distinguishing the magmatic formation of Yakutia, by N. I. Nenashev;

36. New data on age relationships in cores of deep-sea oozes, by V. I. Baranov, and L. A. Kuz'mina;

37. Towards the question of anionic method of age determination, by Kuznetsov;

38. The spectroscopic determination of rubidium in potassium minerals, by L. N. Ovchinnikov and N. A. Yaposh;

39. Means of increasing the accuracy of determination of radiogenic argon by isotopic dilution, by L. L. Shanin;

40. Information on the activities of the age laboratories of the I. G. E. M. of the Academy of Sciences of the U. S. S. R., by A. D. Yesikov;

41. Determination of rubidium minerals and rocks, by L. G. Vlasov

42. Information on papers from the Western Siberia branch of the Academy of Sciences of the U. S. S. R., by A. N. Vorsin;

43. A radio-frequency mass spectrometer for determining the absolute age of rocks by the potassium-argon method, by A. N. Vorsin.

T. B. Pekarskaya

GENERAL MEETING OF THE DEPARTMENT OF GEOLOGICAL AND GEOGRAPHICAL SCIENCES OF THE ACADEMY OF SCIENCES OF THE U. S. S. R. IN CELEBRATION OF THE 40TH ANNIVERSARY OF THE GREAT OCTOBER SOCIALIST REVOLUTION

To mark the occasion of the 40th anniversary of the Revolution, a general meeting was held in Moscow from October 29 to 30, 1957. After an introduction by Academician D. I. Shcherbakov, secretary of the D. G. G. S. the following papers were presented:

1. Granites of geosynclines and platforms on a geologic map, by Academician D. V. Nalivkin;

2. The progress of geology in Azerbaidzhan during the Soviet period, by Academician M. M. Aliyer of the Azerbaidzhan S. S. R.;

3. Biostratigraphy and geochronology of continental deposits, by L. I. Gorskiy, corresponding member of the Academy of Sciences of the U. S. S. R.;

4. Genetic types of deposits of rare elements, by K. A. Ulasov, corresponding member of the Academy of Sciences of the U. S. S. R.;

5. Some of the main problems of physical geography, by Academician A. A. Grigor'ev;

6. Regular distribution of life in the ocean, by L. A. Zenkevich, corresponding member of the Academy of Sciences of the U. S. S. R., and Professors V. G. Bogorov and V. I. Usachev;

7. An atlas of paleogeographic maps of the Ukrainian and Moldavian S. S. R., by Academician V. G. Bondarchuk of the Academy of Sciences of the Ukrainian S. S. R., and Professor P. N. Shul'ga.

At the concluding session, the problems proposed for study in 1958 were discussed and approved.

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1. Articles on the following geological topics are printed in the Izvestiya of the Academy of Sciences, USSR: general and historical geology, tectonics, stratigraphy, petrography, mineralogy, geochemistry, lithology, deposits of economic importance, etc., as well as the history of these sciences.

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